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Popular Mechanics

SCIENCE TECHNOLOGY AUTOMOTIVE HOME ADVENTURE



POPULARMECHANICS.COM OCTOBER 2011

NEW KITS,
TECH AND
MATERIALS

BUILD YOUR OWN PLANE!

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ALSO IN
THIS ISSUE

- HOW TO MAKE A T-SHIRT BAZOOKA
- SAVE MONEY WITH OUR CAR-PAINT TOUCHUP TIPS
- PM DESIGNS A BETTER MILITARY HUMVEE
- WE TEST 8 LEAF BLOWERS FOR \$160 OR LESS!
- FUTURE HOME TECH: 22 ENERGY-SAVING IDEAS

CORY BIRD'S CARBON-FIBER AIRCRAFT HAS BEEN CALLED THE PERFECT PLANE.





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PopMech
Oct.

The PM
test crew
rumbles across
Michigan's
Upper
Peninsula.



62 DIY Flight Readily available engineering software and lenient regulations make the United States the ideal place to design, build and fly your own airplane. But even as amateur aeronautical engineers use their formidable talents to create amazing flying machines, they know that one tiny flaw can be deadly. **BY JEFF WISE**

70 Super Storms Scientists say it's only a matter of time before a massive tornado or hurricane smashes into one of the nation's most populated areas. PM reveals the ways that cities across the U.S. are preparing for disaster by studying how worst-case scenarios might unfold. **BY DOUGLAS FOX**

78 Rethinking the Home of the Future In a contest to build net-zero houses, which produce as much energy as they consume, students in the 2011 Solar Decathlon defy conventional construction ideas and techniques with bold new ideas, next-gen technology and wide-open minds. **BY HARRY SAWYERS**

84 Good to Go Copper mines, dirt back roads and miles of lakeside asphalt are just some of the ingredients for the ultimate joy ride on Michigan's Upper Peninsula. PM tests five adventure-touring bikes—the SUVs of the motorcycle world—on roads, rocks and everything in between. **BY SAM SMITH**

*On
the
cover*

DIY plane designer Cory Bird used carbon fiber to fabricate his beautiful two-seater, *Symmetry*, seen here in Mojave, Calif., in May. This aeronautical work of art features a 200-hp engine and can reach 284 mph. Photograph by Jason Madara.

PHOTOGRAPH BY **JAMES MINCHIN**

DEPARTMENTS

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Plus: A camera that lets you focus after the shot; how to land on an asteroid.

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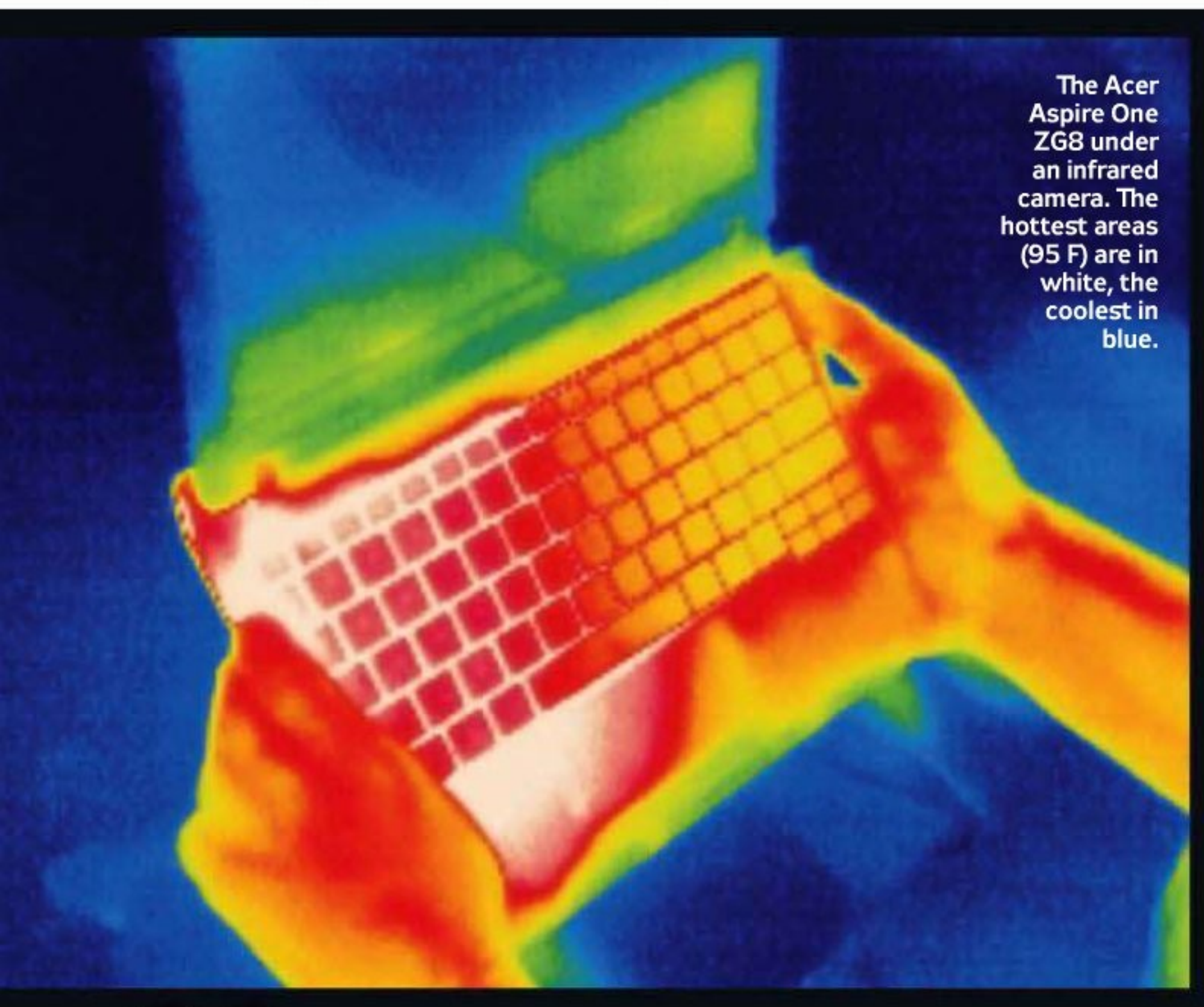
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Plus: We test the DeWalt Heavy Duty Work Stand and rank 11 gadgets released this month—some amazing, some less so.

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Plus: Tech that gives smaller, high-efficiency engines the power without the thirst.



The Acer Aspire One ZG8 under an infrared camera. The hottest areas (95 F) are in white, the coolest in blue.

“Stick your hand behind the ventilation grille of an HDTV or a cable box, or feel the bottom of your laptop. These things are like space heaters.” — Digital Clinic, page 96

Columns

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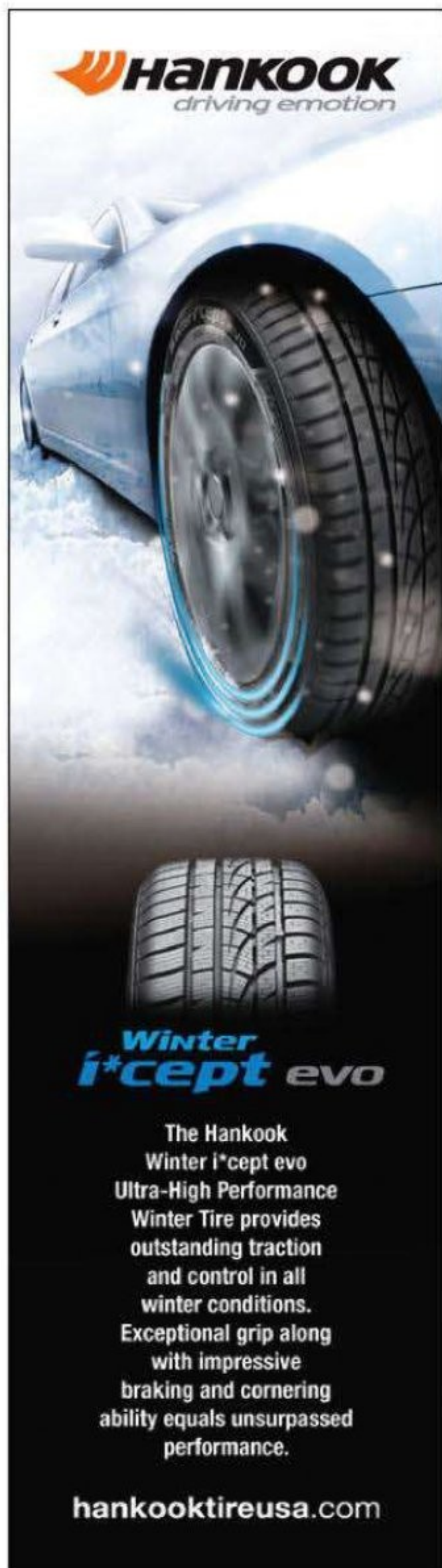
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PM LETTERS

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Scuba diving at Ohio's White Star Quarry, reader Bruce Bennett of Chardon, Ohio, goes deep with his "101 Gadgets" issue of POPULAR MECHANICS. "I read PM cover to cover," he says. "It always has such a wonderful variety of subject matter." The fish seem to agree!

May) was great, but there's one problem: I have a wife, kids, a dog and a mortgage, and the only time I seem to have to myself is in the shower! Can you *please* do an article on showerheads that totally waste water and provide the most relaxing shower in the world? That way, these 10 minutes a day would be heaven.

E.J. LONG PHILADELPHIA

Jay Leno Is One of Us

As someone who has rebuilt his own cars, I always look forward to Jay Leno's column. I feel that he's a real car guy, not just some overeducated engineer who talks a good story. He loves cars like the rest of us do. When I read his column I feel like I'm talking to one of the guys.

NORMAN CLARK WELLBORN, FL

Flying Lessons

Your August story "Flight Risks," exploring the Air France Flight 447 crash and the safety of automated cockpits, addresses some serious problems. I flew about half of my 5500 hours in the equally large C-5 but "grew up" in fighters. Stalls were no big deal in the aerobatic planes. I was stunned, however, to see so many transport pilots crash high-altitude stalls in simulations. They simply couldn't bring themselves to hold the yoke full-forward long enough to break the stall. That's what happened to Air France and could happen again today to nearly any transport crew. Teaching airline pilots to fly the violent maneuvers required to save a plane in these situations must be included in sim training. Let's emphasize basic aircraft control and reevaluate an airline culture that values being smooth over being skilled.

ED HERLIK COLORADO SPRINGS, CO

Where's the Flood?

Your article about the best showerheads that meet EPA regulations ("How Your House Works: Shower Power,"

Garages Are for Women Too—Of Course!

POPULAR MECHANICS is one of my favorite magazines, and I especially enjoyed the article about DIY garages ("The Ultimate Garage," August). But why the "domesticated residential world" dig at mothers, girlfriends and wives? As a woman, I'd love to have a garage space all my own (complete with a welding station!), and I'd never prevent my engineer boyfriend from having a space for himself as well. Please don't forget your female readers, who love the same things you do. ASHLEY HENNEFER RENO, NV

From our fans
and followers

Hello, PM readers on Facebook and Twitter—and thank you for responding to our stories. Here are some recent comments:

Great megabug photos to gross out your students.
@SPONGELAB, VIA TWITTER
("Megabugs: The World's Largest Insects," *popularmechanics.com*)

POPULAR MECHANICS has this feature on the U.S. Navy SEALs. Good stuff!
@POINTBLANK2108, VIA TWITTER
("Secrets of the Navy SEALs," *popularmechanics.com*)

In response to "Backyard Battle: Gas vs. Electric Lawn Tools," from the PM site:

Gas-powered machines are still the most reliable and best.
NKULULEKO SIMELANE,
VIA FACEBOOK

Electric. I hate the gas ones.
DAN MATHIAS, VIA FACEBOOK

Old-school hand tools sharpened and oiled are still among the best.
MICHELE FERLISI, VIA FACEBOOK

I'm a gas man. :D
DAN GRAVEEN, VIA FACEBOOK

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do you
think?

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TechWatch



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Technicians in France have finished a mosaic of 106 detectors, forming a billion-pixel digital camera for the European Space Agency's Gaia mission. Due to launch in 2013, Gaia will be stationed about 930,000 miles from Earth. There, its goal is to map a billion stars during a five-year survey. While the camera will be the largest ever based in space, it is dwarfed by the

3-billion-pixel Large Synoptic Survey Telescope being built in northern Chile.



THE WORLD'S BIGGEST RAFT

A massive natural gas extracting, processing and storage facility anchored about 125 miles off the coast of Australia will become the largest floating structure in the world. Royal

Dutch Shell will build a floating liquefied-natural-gas (LNG) unit stretching more than 530 yards long and weighing more than 600,000 tons—six times heavier than the largest aircraft carriers. The facility will allow gas to be liquefied and shipped, rather than moved in pipelines.



UNDERWATER ACOUSTICS

Microphones pick up small vibrations created by pressure waves of sound, but underwater the pressure makes those sound waves so subtle that they're hard to detect. Naval engineers trying to create a versatile underwater microphone are

also hampered by the huge range in pressure. Stanford researchers created a hydrophone that, like the ears of orca whales, fills with water to equalize pressure. It also uses a laser system to detect vibrations at any depth.

COSMIC DISCOVERY

Fumble & Recovery



When a malfunctioning parachute caused the Genesis probe to crash in 2004, many thought that the mission—NASA's first to return extraterrestrial material to Earth since Apollo's final moon landing in 1972—ended in failure. Indeed, the crash in Utah destroyed most of the samples of solar wind (particles ejected into space from the sun) collected a million miles from Earth. But researchers salvaged particles from undamaged detectors and this year published their first analysis. The samples revealed that solar wind contains higher levels of the most common oxygen isotope than do Earth and other inner planets. This provides strong evidence that the planets and the sun did not form from the same materials; the sun was shining when Earth formed. — ALEX HUTCHINSON



GENESIS RETURN CAPSULE

Weight: 496 lb
Diameter: 60 in.

MISSION

Duration: 1127 days
Solar wind collection: 884 days
Distance traveled: 20 million miles
Impact speed: 193 mph

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SAMPLE COLLECTORS
PROTECTED SOME SOLAR
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RETRIEVAL IN A
CLEAN ROOM

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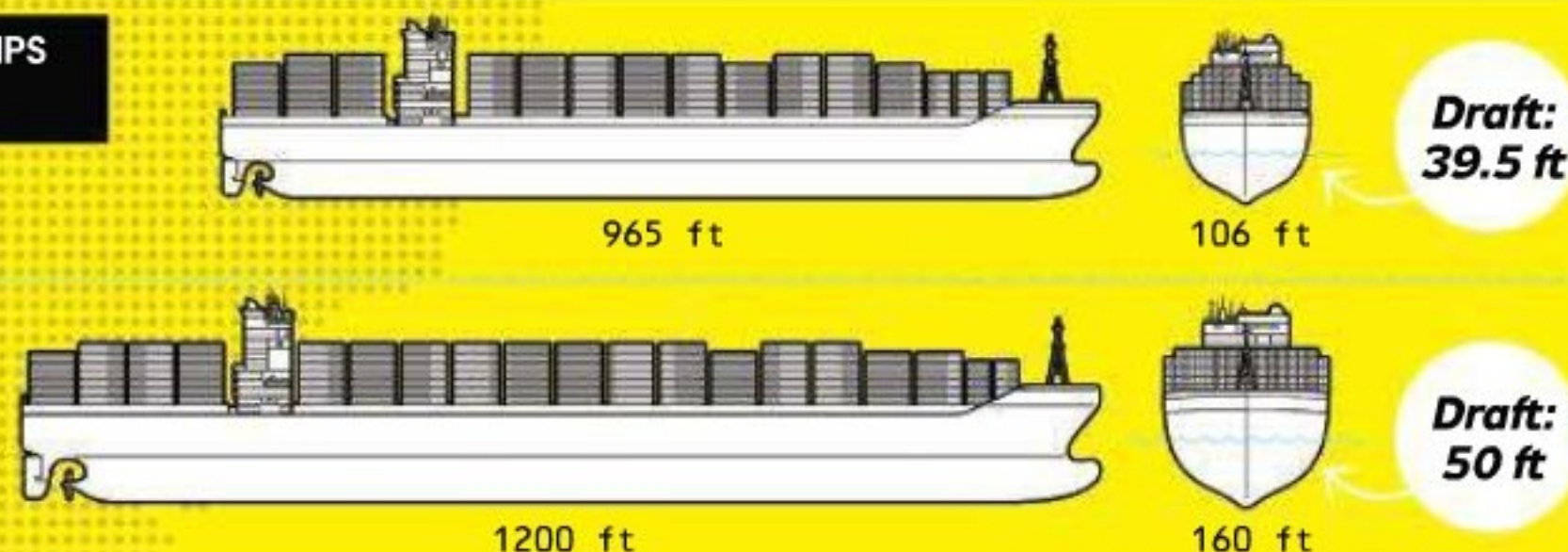
AMERICAN INFRASTRUCTURE

Prepping for Bigger Boats

➔ The operators of the Panama Canal are widening and deepening the waterway to allow larger ships to access the Atlantic and Pacific oceans starting in 2014. Even as port operators prepare for the vessels (see below), work on other vital trade connections is lagging. Experts such as Paul Bingham, an economist with the transportation consulting firm Wilbur Smith Associates, say U.S. road and rail networks are unprepared for the increase in commerce. "The most critical problems are in urban areas near the ports," Bingham says. "These are dense regions without a lot of room to expand." Ships will unload twice as much cargo, causing logistical gridlock, says Johanna Mendelson Forman, senior associate with the Americas Program at the Center for Strategic and International Studies. "Railroads are at capacity in the U.S., and we have not invested what we need to be competitive," Bingham says the clock is ticking: "Three years is a blink of an eye. It's almost too late." —AMIR KHAN

GROWING CARGO SHIPS

Panamax
New Panamax

**Bayonne, N.J. ➔**

The Bayonne Bridge at the mouth of Newark Bay has a clearance of just 151 feet—even current ships have a hard time fitting beneath it. The Port Authority of New York and New Jersey recently approved a \$1 billion plan to raise the bridge to 215 feet. Construction is expected to begin within two years and to be completed by 2016. Officials say the bridge will remain open to traffic during construction.

Baltimore, Md. ➔

Engineers have been increasing the depth of this shipping channel from 45 feet to 50 feet to accommodate New Panamax ships at the docks. The \$105 million project will be finished in 2012, two years ahead of the 2014 opening of the expanded canal. Officials credit the quick work to the establishment of a public-private partnership that spared the project from budget cuts at the state level.

Charleston, S.C. ➔

The port currently supports larger Panamax ships only at high tide. This year, local officials and the U.S. Army Corps of Engineers approved a study to investigate the environmental and economic impact of dredging the channel. But a lack of funding could delay the analysis for eight years, long after the new canal opens to ship traffic. Dredging, if it happens, could cost \$310 million.

Savannah, Ga. ➔

Big ships destined for Savannah are filled to half-capacity and enter the port during high tide in order to avoid scraping the river bottom. The state has partially funded an impending dredging project, but local environmentalists express concern that deepening the channel could decrease the already depleted dissolved oxygen levels in the river and introduce salt into freshwater wetlands.

DIGITAL FUTURE

Life Beyond Flash?

➔ A replacement for a computer's flash memory is closer, thanks to a new advance by IBM. Phase-change memory (PCM) relies on specialized material that transforms from a highly organized crystalline structure to an amorphous form when voltage is applied. Like flash, PCM involves no moving parts and retains information even when the power is turned off. But it can also read and write data 100 times faster than flash and can endure millions of times more read-write cycles. The IBM research shows that a multilevel form of PCM can store information without errors for at least five months, a significant improvement upon previous versions.

—ALEX HUTCHINSON

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PAST LIVES

Did Dino Blood Run Hot or Cold?



⇒ A team of researchers led by Caltech has developed a new technique to help settle the long-standing debate about the body temperature of dinosaurs. The team analyzed the concentrations of carbon-13 and oxygen-18 isotopes in 11 dino teeth dug up in the western U.S. and Tanzania. Since those two isotopes clump in a predictable way depending on temperature, the researchers were able to conclude that

Brachiosaurus had a body temperature within a degree or two of 100.8 F, and *Camarasaurus*, 96.3 F. While those temperatures are similar to that of humans today, it doesn't necessarily mean dinos were warmblooded: Their large size may have allowed them to conserve heat efficiently. The new data will have to be incorporated into dinosaur physiological models, along with factors, such as the spacing between fossilized tracks, that offer clues about the speed of dinosaur metabolism. —ALEX HUTCHINSON

MANNED SPACEFLIGHT



NASA's New Space Plane

→ Sierra Nevada Corp. received \$80 million this year to develop its Dream Chaser space plane (above), aiming for a 2015 test flight. The money is part of NASA's Commercial Crew Development program, which is funding research on a manned spacecraft that would replace the space shuttle. Dream Chaser is the only space plane in the CCD program; two craft in development are capsules, and the third would take off and land vertically. Dream Chaser would launch atop an Atlas V rocket, dock with the International Space Station and land on a runway.

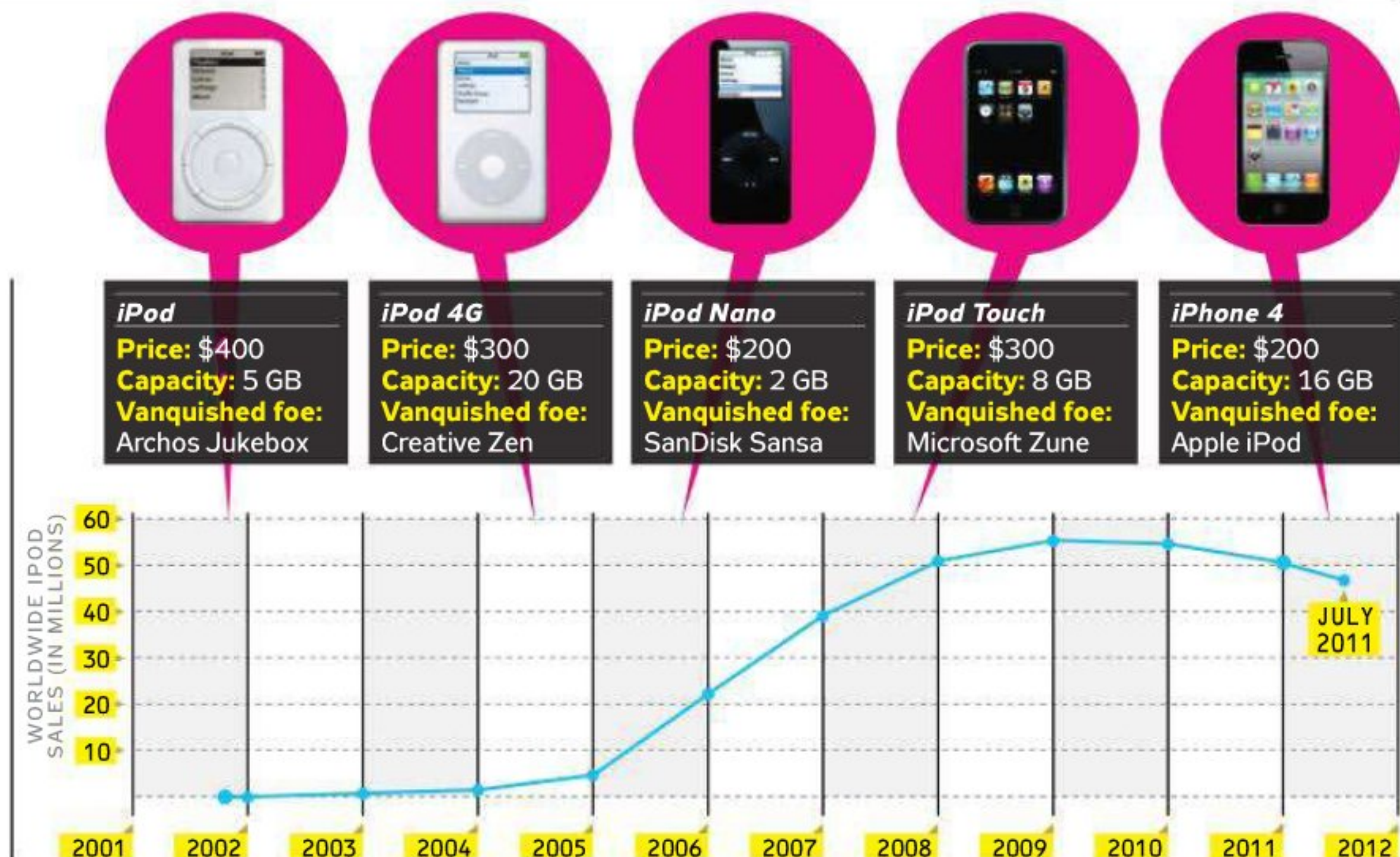
—JOE PAPPALARDO

THE IPOD DECADE

Change of Tunes

→ On Oct. 23, 2001, Apple introduced its first portable music player, the iPod, to mixed reviews. Ten years and 315 million sales later, the iPod's influence on consumer technology is hard to overstate. But the iPod era is coming to a close. Smartphones with music and video players are replacing the iPod, along with the category it helped create.

—JOHN HERRMAN





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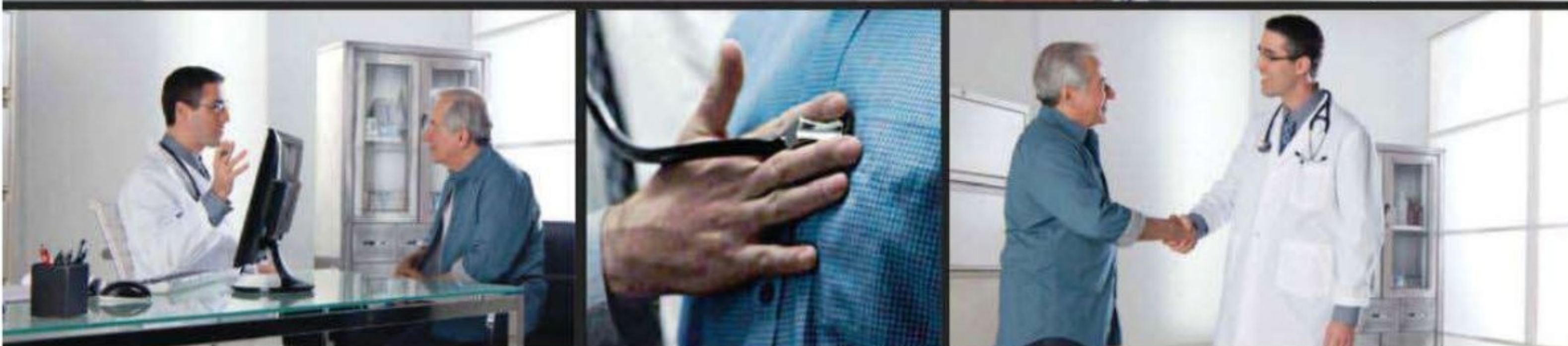
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Dr. Dennis Finkelstein
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and for more information about PRADAXA call 1-877-PRADAXA or visit pradaxa.com.

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Here's why you should ask your doctor about **PRADAXA**.

- In a clinical trial, PRADAXA 150 mg **reduced stroke risk 35% more than warfarin.**
Risk reduction was greatest when compared to patients on warfarin whose blood tests showed lower levels of control.
- **Unlike warfarin, no regular blood tests.**

PRADAXA is a prescription blood-thinning medicine used to reduce the risk of stroke and blood clots in people with atrial fibrillation not caused by a heart valve problem. With atrial fibrillation, part of the heart does not beat the way it should. This can cause blood clots to form, increasing your risk of a stroke. PRADAXA lowers the chance of blood clots forming in your body.

IMPORTANT SAFETY INFORMATION ABOUT PRADAXA

PRADAXA can cause bleeding which can be serious and sometimes lead to death. Don't take PRADAXA if you currently have abnormal bleeding or if you have ever had an allergic reaction to it. **Your risk of bleeding with PRADAXA may be higher if you:** are 75 years old or older, have kidney problems, have stomach or intestine bleeding that is recent or keeps coming back or you have a stomach ulcer, take other medicines that increase your risk of bleeding, like aspirin products, non-steroidal anti-inflammatory drugs (NSAIDs) and blood thinners.

Call your doctor or seek immediate medical care if you have any of the following signs or symptoms of bleeding: any unexpected, severe, or uncontrollable bleeding; or bleeding that lasts a long time, unusual or unexpected bruising,

coughing up or vomiting blood; or vomit that looks like coffee grounds, pink or brown urine; red or black stools (looks like tar), unexpected pain, swelling, or joint pain, headaches and feeling dizzy or weak.

It is important to tell your doctor about all medicines, vitamins and supplements you take. Some of your other medicines may affect the way PRADAXA works.

Take PRADAXA exactly as prescribed by your doctor. Don't stop taking PRADAXA without talking to your doctor as your risk of stroke may increase.

Tell your doctor if you are planning to have **any** surgery, or medical or dental procedure, because you may have to stop taking PRADAXA for a short time. PRADAXA can cause indigestion, stomach upset or burning, and stomach pain.

You are encouraged to report negative side effects of prescription drugs to the FDA.

Visit www.fda/medwatch or call 1-800-FDA-1088.

Please see more detailed Medication Guide on next page.

Reduce your risk of a stroke caused by a clot that starts in the heart.

Pradaxa[®]
dabigatran etexilate
CAPSULES

MEDICATION GUIDE
PRADAXA (pra dax' a)
(dabigatran etexilate mesylate)
capsules

Read this Medication Guide before you start taking PRADAXA and each time you get a refill. There may be new information. This Medication Guide does not take the place of talking with your doctor about your medical condition or your treatment.

What is the most important information I should know about PRADAXA?

- PRADAXA can cause bleeding which can be serious, and sometimes lead to death. This is because PRADAXA is a blood thinner medicine that lowers the chance of blood clots forming in your body.
- **You may have a higher risk of bleeding if you take PRADAXA and:**
 - Are over 75 years old
 - Have kidney problems
 - Have stomach or intestine bleeding that is recent or keeps coming back, or you have a stomach ulcer
 - Take other medicines that increase your risk of bleeding, including:
 - aspirin or aspirin containing products
 - long-term (chronic) use of non-steroidal anti-inflammatory drugs (NSAIDs)
 - warfarin sodium (Coumadin[®], Jantoven[®])
 - a medicine that contains heparin
 - clopidogrel (Plavix[®])
 - prasugrel (Effient[®])

Tell your doctor if you take any of these medicines. Ask your doctor or pharmacist if you are not sure if your medicine is one listed above.

- PRADAXA can increase your risk of bleeding because it lessens the ability of your blood to clot. While you take PRADAXA:
 - You may bruise more easily
 - It may take longer for any bleeding to stop

Call your doctor or get medical help right away if you have any of these signs or symptoms of bleeding:

- Unexpected bleeding or bleeding that lasts a long time, such as:
 - unusual bleeding from the gums
 - nose bleeds that happen often
 - menstrual bleeding or vaginal bleeding that is heavier than normal
- Bleeding that is severe or you cannot control
- Pink or brown urine
- Red or black stools (looks like tar)
- Bruises that happen without a known cause or get larger
- Cough up blood or blood clots
- Vomit blood or your vomit looks like "coffee grounds"
- Unexpected pain, swelling, or joint pain
- Headaches, feeling dizzy or weak

Take PRADAXA exactly as prescribed. Do not stop taking PRADAXA without first talking to the doctor who prescribes it for you. Stopping PRADAXA may increase your risk of a stroke.

PRADAXA may need to be stopped, if possible, for one or more days before any surgery, or medical or dental procedure. If you need to stop taking PRADAXA for **any reason**, talk to the doctor who prescribed PRADAXA for you to find out when you should stop taking it. Your doctor will tell you when to start taking PRADAXA again after your surgery or procedure.

See "What are the possible side effects of PRADAXA?" for more information about side effects.

What is PRADAXA?

PRADAXA is a prescription medicine used to reduce the risk of stroke and blood clots in people who have a medical condition called atrial fibrillation. With atrial fibrillation, part of the heart does not beat the way it should. This can lead to blood clots forming and increase your risk of a stroke. PRADAXA is a blood thinner medicine that lowers the chance of blood clots forming in your body.

It is not known if PRADAXA is safe and works in children.

Who should not take PRADAXA?

Do not take PRADAXA if you:

- Currently have certain types of abnormal bleeding. Talk to your doctor, before taking PRADAXA if you currently have unusual bleeding.
- Have had a serious allergic reaction to PRADAXA. Ask your doctor if you are not sure.

What should I tell my doctor before taking PRADAXA?

Before you take PRADAXA, tell your doctor if you:

- Have kidney problems
- Have ever had bleeding problems
- Have ever had stomach ulcers
- Have any other medical condition
- Are pregnant or plan to become pregnant. It is not known if PRADAXA will harm your unborn baby.
- Are breastfeeding or plan to breastfeed. It is not known if PRADAXA passes into your breast milk.

Tell all of your doctors and dentists that you are taking PRADAXA. They should talk to the doctor who prescribed PRADAXA for you, before you have **any** surgery, or medical or dental procedure.

Tell your doctor about all the medicines you take, including prescription and non-prescription medicines, vitamins, and herbal supplements. Some of your other medicines may affect the way PRADAXA works. Certain medicines may increase your risk of bleeding. See "What is the most important information I should know about PRADAXA?"

Especially tell your doctor if you take:

- rifampin (Rifater, Rifamate, Rimactane, Rifadin)

Know the medicines you take. Keep a list of them and show it to your doctor and pharmacist when you get a new medicine.

How should I take PRADAXA?

- **Take PRADAXA exactly as prescribed by your doctor.**
- Do not take PRADAXA more often than your doctor tells you to.
- You can take PRADAXA with or without food.
- Swallow PRADAXA capsules whole. Do not break, chew, or empty the pellets from the capsule.
- If you miss a dose of PRADAXA, take it as soon as you remember. If your next dose is less than 6 hours away, skip the missed dose. Do not take two doses of PRADAXA at the same time.
- Your doctor will decide how long you should take PRADAXA. **Do not stop taking PRADAXA without first talking with your doctor. Stopping PRADAXA may increase your risk of stroke.**
- Do not run out of PRADAXA. Refill your prescription before you run out. If you plan to have surgery, or a medical or a dental procedure, tell your doctor and dentist that you are taking PRADAXA. You may have to stop taking PRADAXA for a short time. See "What is the most important information I should know about PRADAXA?"
- If you take too much PRADAXA, go to the nearest hospital emergency room or call your doctor or the Poison Control Center right away.

What are the possible side effects of PRADAXA?

PRADAXA can cause serious side effects.

- See "What is the most important information I should know about PRADAXA?"
- Allergic Reactions. In some people, PRADAXA can cause symptoms of an allergic reaction, including hives, rash, and itching. Tell your doctor or get medical help right away if you get any of the following symptoms of a serious allergic reaction with PRADAXA:
 - chest pain or chest tightness
 - swelling of your face or tongue
 - trouble breathing or wheezing
 - feeling dizzy or faint

Common side effects of PRADAXA include:

- indigestion, upset stomach, or burning
- stomach pain

Tell your doctor if you have any side effect that bothers you or that does not go away.

These are not all of the possible side effects of PRADAXA. For more information, ask your doctor or pharmacist.

Call your doctor for medical advice about side effects. You may report side effects to FDA at 1-800-FDA-1088.

How should I store PRADAXA?

- Store PRADAXA at room temperature between 59°F to 86°F (15°C to 30°C). After opening the bottle, use PRADAXA within 30 days. Safely throw away any unused PRADAXA after 30 days.
- Store PRADAXA in the original package to keep it dry. Keep the bottle tightly closed.

Keep PRADAXA and all medicines out of the reach of children.

General information about PRADAXA

Medicines are sometimes prescribed for purposes other than those listed in a Medication Guide. Do not use PRADAXA for a condition for which it was not prescribed. Do not give your PRADAXA to other people, even if they have the same symptoms. It may harm them.

This Medication Guide summarizes the most important information about PRADAXA. If you would like more information, talk with your doctor. You can ask your pharmacist or doctor for information about PRADAXA that is written for health professionals.

For more information, go to www.PRADAXA.com or call 1-800-542-6257 or (TTY) 1-800-459-9906.

What are the ingredients in PRADAXA?

Active ingredient: dabigatran etexilate mesylate

Inactive ingredients: acacia, dimethicone, hypromellose, hydroxypropyl cellulose, talc, and tartaric acid. The capsule shell is composed of carrageenan, FD&C Blue No. 2, FD&C Yellow No. 6, hypromellose, potassium chloride, titanium dioxide, and black edible ink.

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19 REASONS TO PAY ATTENTION TO WASHINGTON—AND NOT ONE RELATED TO POLITICS



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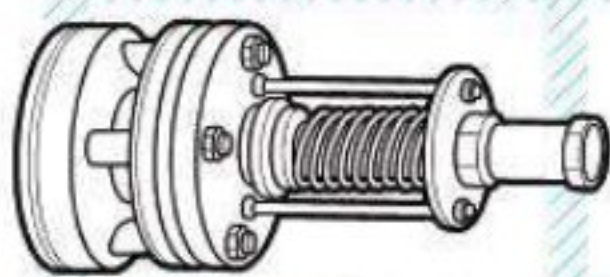


How to Harpoon an Asteroid

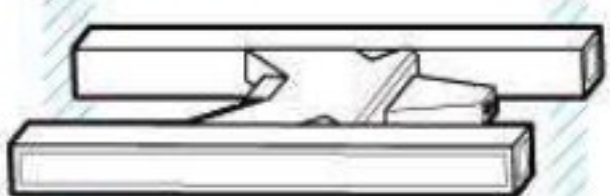
→ **NASA plans to send astronauts** to an unspecified asteroid by 2025—but how the spacecraft carrying them will land is still an open question; an asteroid's gravity is too weak to hold a lander. Instead, astronauts will have to grapple the asteroid to secure their ship to its surface. Inspired by fishermen, hikers and mountaineers, researchers at MIT are investigating techniques for shooting projectiles into the rock to stabilize spacecraft with cables. A capsule could travel down the tether on mechanized rollers or fly around the entire asteroid to wrap it with cable, providing astronauts with downward pressure that would serve as artificial gravity.

Projectiles would need to be tailor-made for each target (see below). "Some asteroids might have a metallic core, and trying to anchor to them would be like banging a nail into an anvil," says Jeffrey Hoffman, a professor of aeronautics and astronautics at MIT and a former astronaut. "Others may just be a rubble pile, which would be like trying to pitch a tent on a snowfield." Astronauts could also use these docking techniques on the moons of Mars—which the Obama administration has cited as possible destinations—because of their similarly weak surface gravity. —ALYSON SHEPPARD

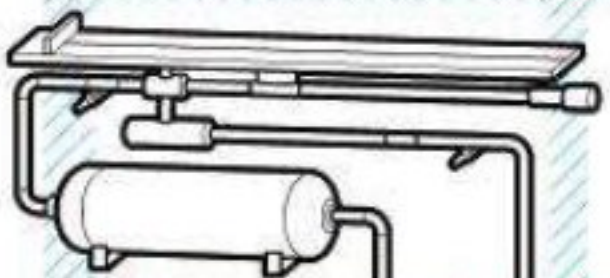
LAUNCHERS



Spring-loaded gun → Simple and lightweight, this launcher could repeatedly shoot a projectile without using an energy source.



Electromagnetic launcher → Two metal rails flank the projectile, zapping it with a large electric current to cause high acceleration.



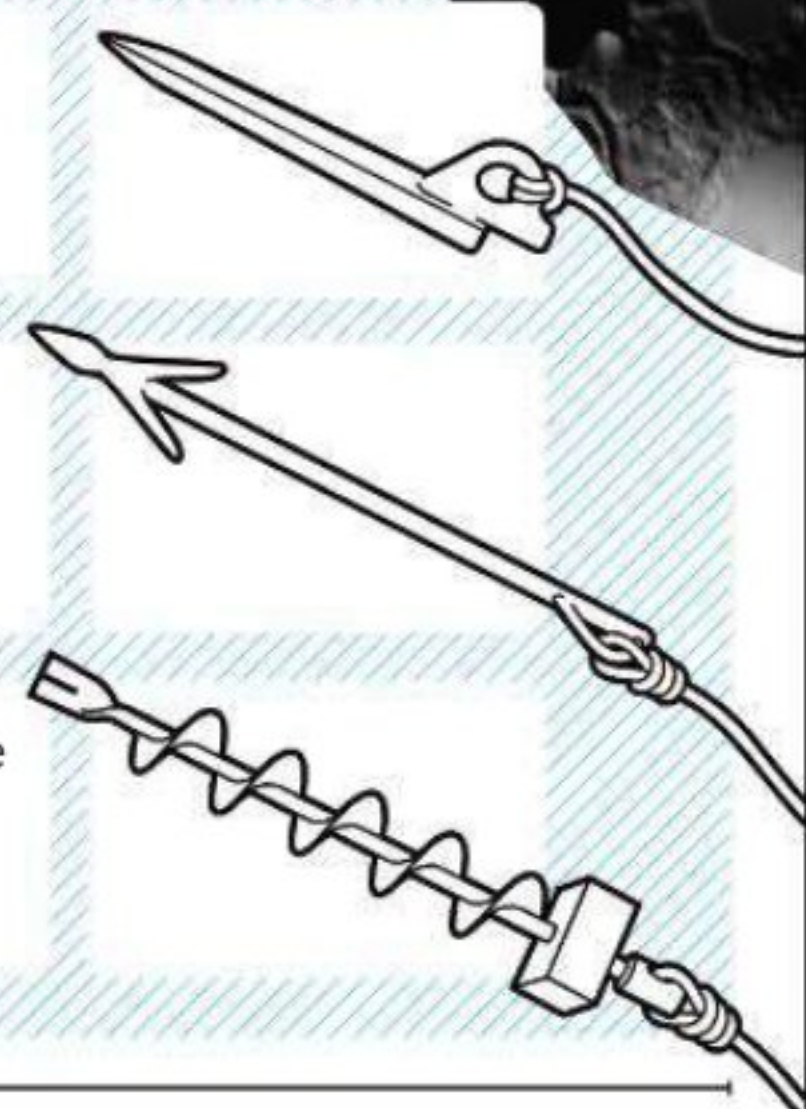
Steam catapult → Steam pressure drives a shuttle carrying the projectile. The shuttle shoots to the end of the rail and propels the projectile into space.

PROJECTILES

Piton → Made of steel alloy and aimed at surface cracks, pitons are well-suited for asteroids with metal cores.

Harpoon → Barbs on the harpoon open once it sinks into rock, preventing the anchor from coming loose.

Corkscrew → After sinking the tip into its target, a motor twists the corkscrew to secure it in granular rubble.



Why not send robots to an asteroid?

People can adapt to unplanned situations much better than robotic systems can. The whole environment of asteroids is still unknown, so the more flexibility we have with anchoring equipment, the more likely we'll be successful. We'll take as many different methods as possible and let the astronauts try them out, make adjustments on the spot, and see which ones work best.

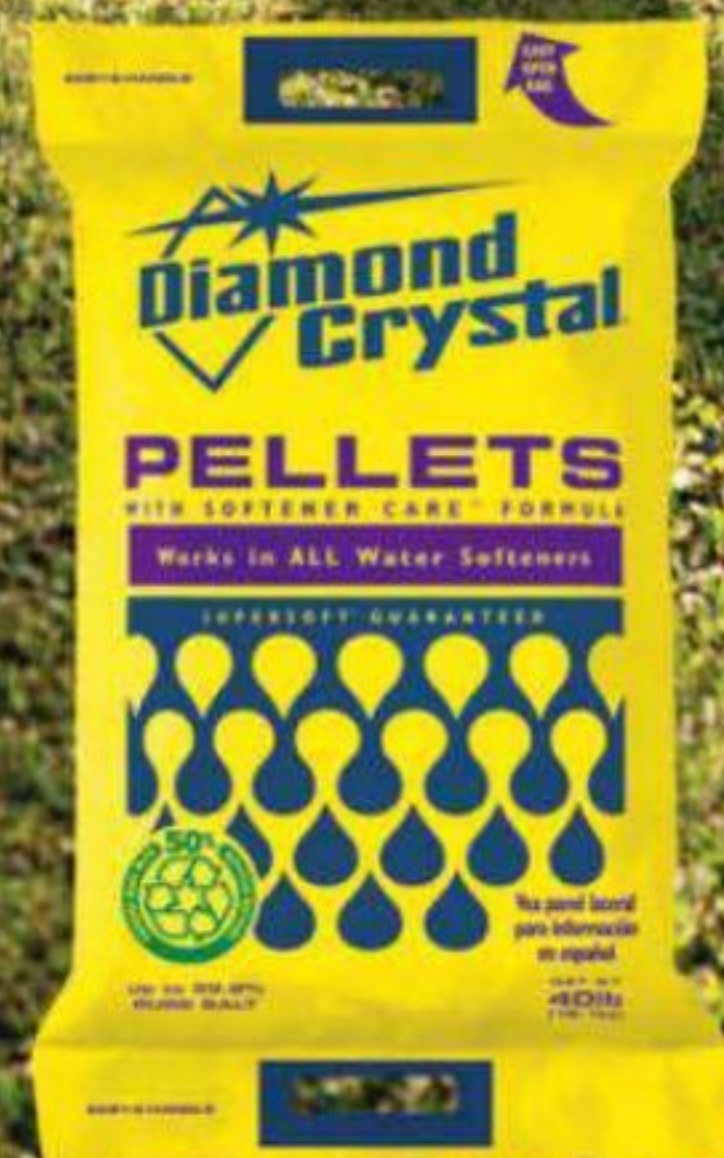
— **JEFFREY HOFFMAN**, professor of aeronautics and astronautics at MIT and five-time space shuttle astronaut

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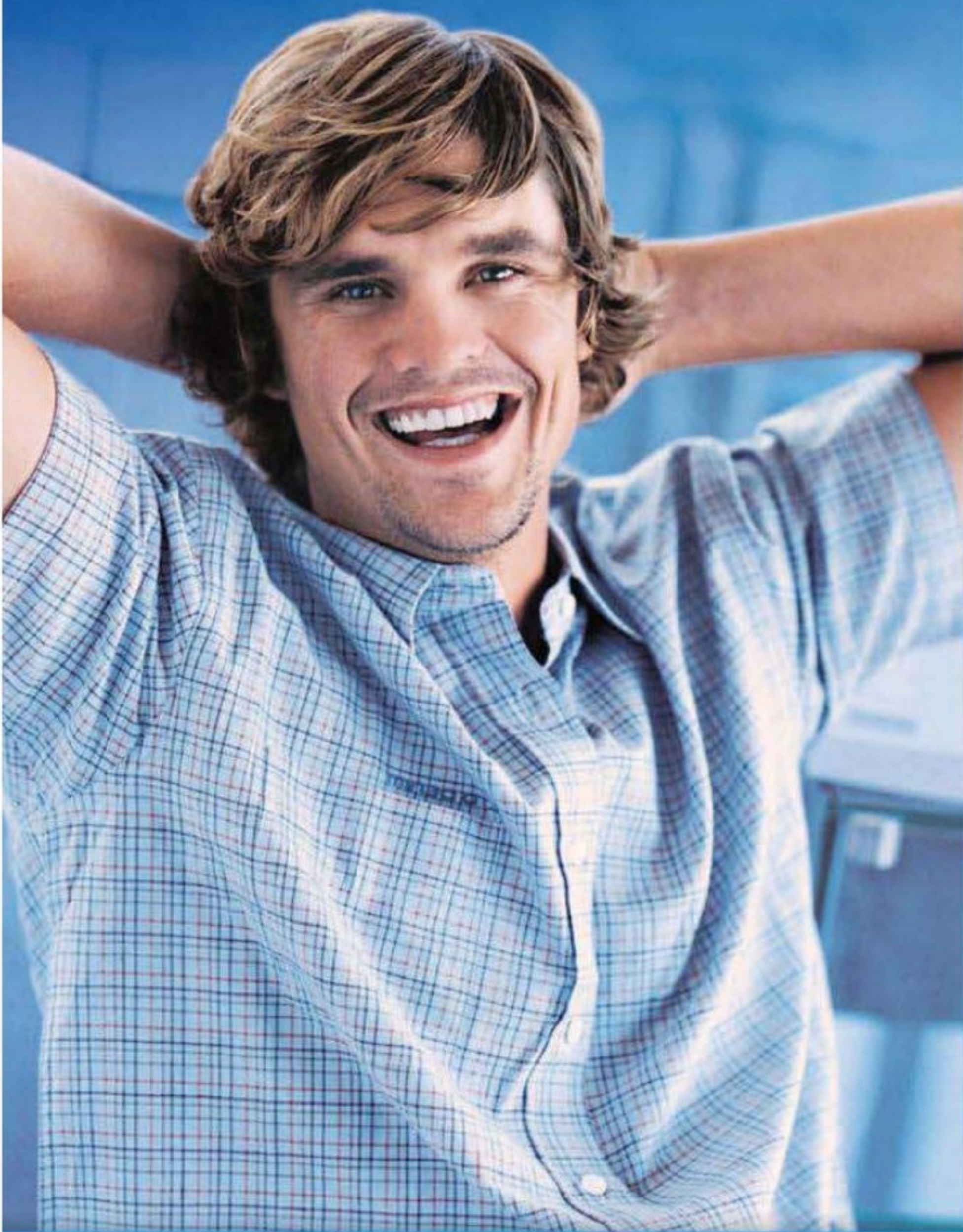
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• THE ART OF PHYSICS

Constant Change

→ Every four years an international group called the Committee on Data for Science and Technology makes public its accepted values for the fundamental constants of nature. That way, for example, every physicist studying quantum mechanics is using the same figure for the size of a proton (right). The committee adjusts these figures in response to more accurate measurements.

— JOE PAPPALARDO

$$r_p = 0.8768(69) \text{ fm}$$

75(51)

PROTON RADIUS

QUANTIFIES THE SIZE OF A FUNDAMENTAL PARTICLE

Recent experiments led the group to recommend a slight increase in the proton's size. This recommendation dismisses as "inconsistent" the results of other recent research, which used an exotic form of hydrogen and suggested that the proton size was smaller.

PLANCK CONSTANT

DEFINES THE SIZE OF THE SMALLEST ENERGIES OF LIGHT PACKETS

Two ways of calculating this constant—one that counts silicon atoms in a pure crystal and another that compares electrical and mechanical power—come up with slightly different values. The new figure reflects the fact that the two values are converging.

CONSTANT OF GRAVITATION

DICTATES THE STRENGTH OF NEWTONIAN GRAVITY

New ways to measure gravity have determined that this constant is slightly less powerful. The value appears in both Einstein's theory of relativity and Newton's law of universal gravitation, but the change does not greatly influence either theory.

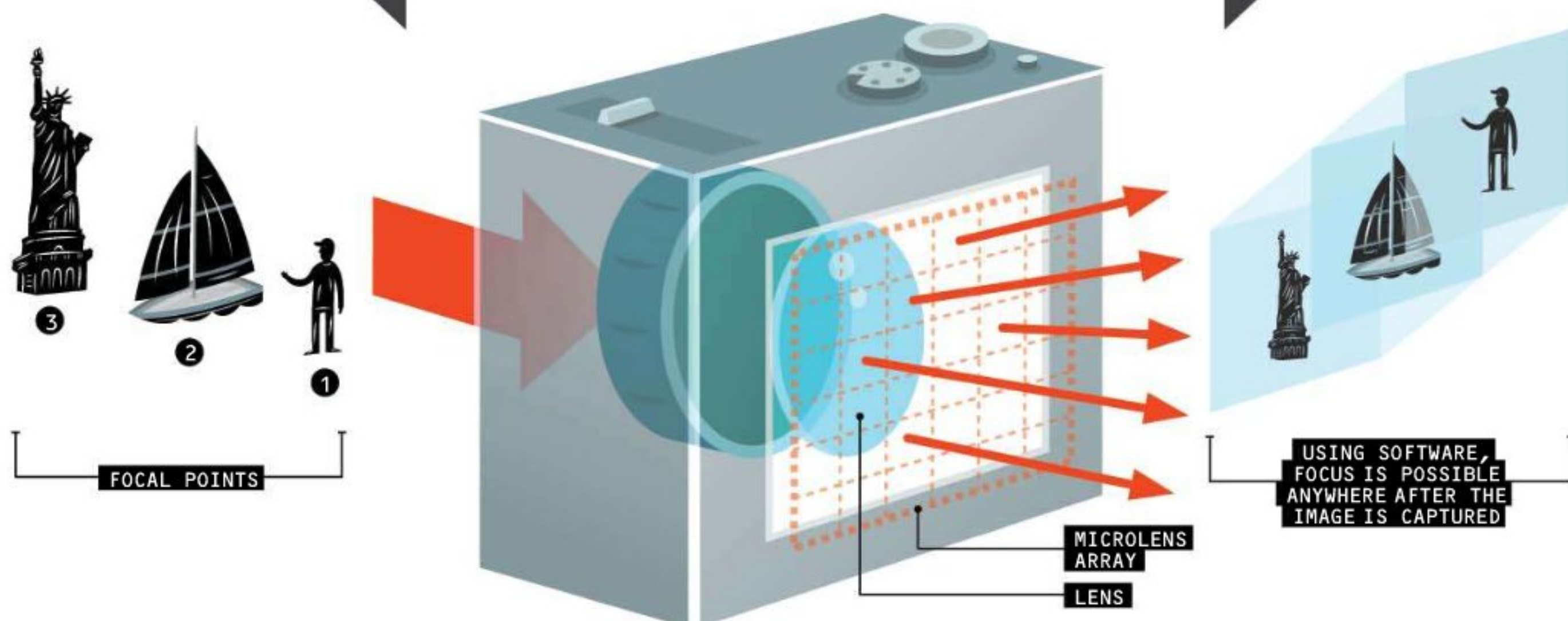
• AMAZING OPTICS

Shoot First, Focus Later

Despite substantial improvements in quality, the way cameras take photographs has barely changed over the past half-century: Point, focus and click to capture a static image. This fall, Lytro, a Silicon Valley startup, plans to release a commercial "light-field camera" that reinvents the time-honored process. — MARY BETH GRIGGS

How does it work? A light field is "the amount of light traveling in every direction in every point in space," says Ren Ng, Lytro's founder. Instead of just recording how much light hits each pixel in the camera's sensor, a light-field system incorporates a microlens array and software to capture the color, intensity and direction of the light rays.

What advantages does it have over a conventional camera? Light-field camera pictures can be refocused after they are taken or converted into 3D images. Also, by inserting a microlens array into a microscope, scientists can observe live specimens from multiple perspectives.



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PREPAREDNESS

AFTER THE STORM

FIRST CAME THE SWARM OF TORNADOES, THEN THE BLACKOUT. OFFICIALS EXAMINE THE AFTERMATH OF A DISASTER TO HELP OTHERS PLAN FOR THE WORST. BY JOE PAPPALARDO



Thousands of workers fanned out in Alabama to repair damaged power lines.

No one in Huntsville, Ala., expected the storms that ravaged it on April 27 to knock the city and surrounding areas off the grid completely. But a series of tornadoes severed all eight major power feeds into Madison County, leaving at least 340,000 northern Alabama residents in the dark for six days. Two months later, federal officials joined a public-private roundtable in Huntsville to review some of the observations that could be applied to other disasters. The risks go beyond weather—cascading equipment failure, solar flares and cyber attacks could also shut down power, making the lessons from Alabama applicable to every citizen, business leader and politician.

ADVICE FOR INDIVIDUALS

SEEK OUT BIG HOTELS ➔ In Huntsville, major hotel chains had fuel for their generators shipped in, enabling people to get online or power cell-phones. "Hotels were one of the best places you could go to connect to the world," says Rodney Robertson, executive director of Auburn University's Huntsville Research Center.

RELY ON BATTERY-OPERATED OR HAND-CRANKED RADIOS ➔ Officials delivered news every morning, and local stations constantly reported updates. "People called in to say, 'Get gas in Athens,' or 'There's a grocery open with ice,'" says Dale Jobes, chair of the Energy Huntsville Initiative, a public-private advocacy group.

ADVICE FOR INDUSTRY

TAKE CARE OF EMERGENCY GENERATORS ➔ Having emergency systems is not enough. "There was a major nationwide retailer here that had a generator to operate their facility in case something like this happened," Robertson says. "But they never maintained it. They never got the generator working during the event."

MAKE SURE SENSITIVE LOCATIONS ARE SECURE ➔ Huntsville is home to many defense-technology firms. After a few days in the dark, the emergency batteries powering security systems died, leaving secret information and facilities unguarded. Better backups, including guards and stockpiles of batteries, are needed.



ADVICE FOR GOVERNMENT

MAINTAIN A LIST OF CRITICAL INFRASTRUCTURE ➔ Some facilities are clear priorities, such as hospitals and nursing homes. Other places may not be so obvious. In Huntsville, the Army's Redstone Arsenal was designated as an industrial center and therefore low on the list to receive public power. But with classified projects under way and vital repair work on tight schedules—not to mention families living on post—the base needed quicker attention.

DIVERSIFY YOUR POWER SUPPLY ➔ One of the benefits of renewable energy is decreased dependence on a centralized grid. For example, despite widespread storm damage, the communities in northern Alabama supplied by a hydroelectric power plant kept their electricity. Using local sources of renewable energy to create redundancy is a smart way to safeguard against the unexpected.



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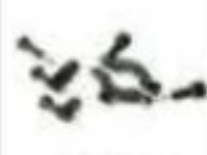
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Upgrade

Stay Tuned

It began as a birthday present and won funding from Kickstarter. Now designer Paula Anne Patterson of Brooklyn, N.Y., is scaling up production of the **BKNYdesign V-luxe iPad Stand (\$499)** from an initial run—of 30. To gauge interest, she showed off an early walnut prototype outside an NYC Apple Store. Several double-takes, guffaws and lots of smiles later, she was back in her shop, carving up V-luxes by hand, by herself. A push-in dowel aligns with the iPad's home button, well-placed holes accommodate the charger and headphone jack, and the cabinet is sized just right for a kickin' pair of Bluetooth-enabled Soundmatters FoxL V2 speakers. The only thing missing is a set of rabbit ears. — HARRY SAWYERS



Genesis of the Tractor



→ Your first car was the family Pinto. Make up for it with a proper first tractor: **John Deere's 1026R (\$12,595)**. (You made enough money to buy a pasture, didn't ya?) More than 25 attachments include a land plane, belly mower, backhoe bucket and the always-popular front-end loader, each of which hooks up by simply driving up to it with the main rig. "Guys buy these with five or six jobs in mind, then take it home and do 20," product manager Dan Paschke says. Got a driveway to grade?

Rough Justice →

Rust on the railing? Weld standing proud? Just want to reduce the surface area of an object by a thousandth of an inch? Fire up 25,000 rpm on a 4.4-pound **Makita 18-Volt Cordless 1/4-Inch Die Grinder (\$169/tool; \$379/kit)** and find out how a monster Dremel would operate.



Light-Headed → If 200 lumens and four brightness settings can't guide you back to camp, maybe you shouldn't stumble off in the dark. Good thing the **Mammut X-Shot Headlamp (\$89)** also has an emergency beacon good for 96 hours of steady, desperate blinking.



PM-TESTED

Stalwart Sawbucks

→ Rated to support up to 1000 pounds apiece, **DeWalt Heavy Duty Work Stands (\$89)** practically invite abuse. With a pair of universal miter-saw mounting brackets (a \$30 add-on), the stands can be configured for a multitude of duties. Our pair held bench-top machinery, suffered merciless percussive strikes, endured circular-saw crosscuts and even served as seating at a sweltering summer barbecue. — **STUART DEUTSCH**

Bench Tools

The mounting brackets have potential beyond just miter saws. After attaching a plywood platform to the brackets, we bolted down a 10-inch drill press and found the stand to be a very stable base for each machine. A disc sander, a bench grinder or a portable planer would also do well.

Jigs and Vises

We mounted a 40-pound bench vise to one of the stands, stuck a foot-long 2 x 4 in its jaws and beat on the board with a 3-pound hammer. A secure footing minimized motion, but the stand did slide a bit. Not bad for a tool meant to support static loads.

Workpieces

We fastened sacrificial 2 x 4s, then used a circular saw to rip plywood sheets with ease. Two stands had no trouble with traditional sawhorse work. Ordinary bar clamps and C-clamps secure small pieces along the rails, and notches and holes at each end hold pipes and accept DeWalt's track-saw clamps.



PROMOTION

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October PopMech iPad App

Each month, the Popular Mechanics team takes every word and picture of the print issue, optimizes it for the iPad and adds interactive functionality to enhance the individual stories. The result? PopMech: a must-download app! This month you'll enjoy the "Build Your Own Plane" cover story, brilliant concepts for the home of the future from the 2011 Solar Decathlon, and in-depth analysis of the disturbing rise of the megastorm.

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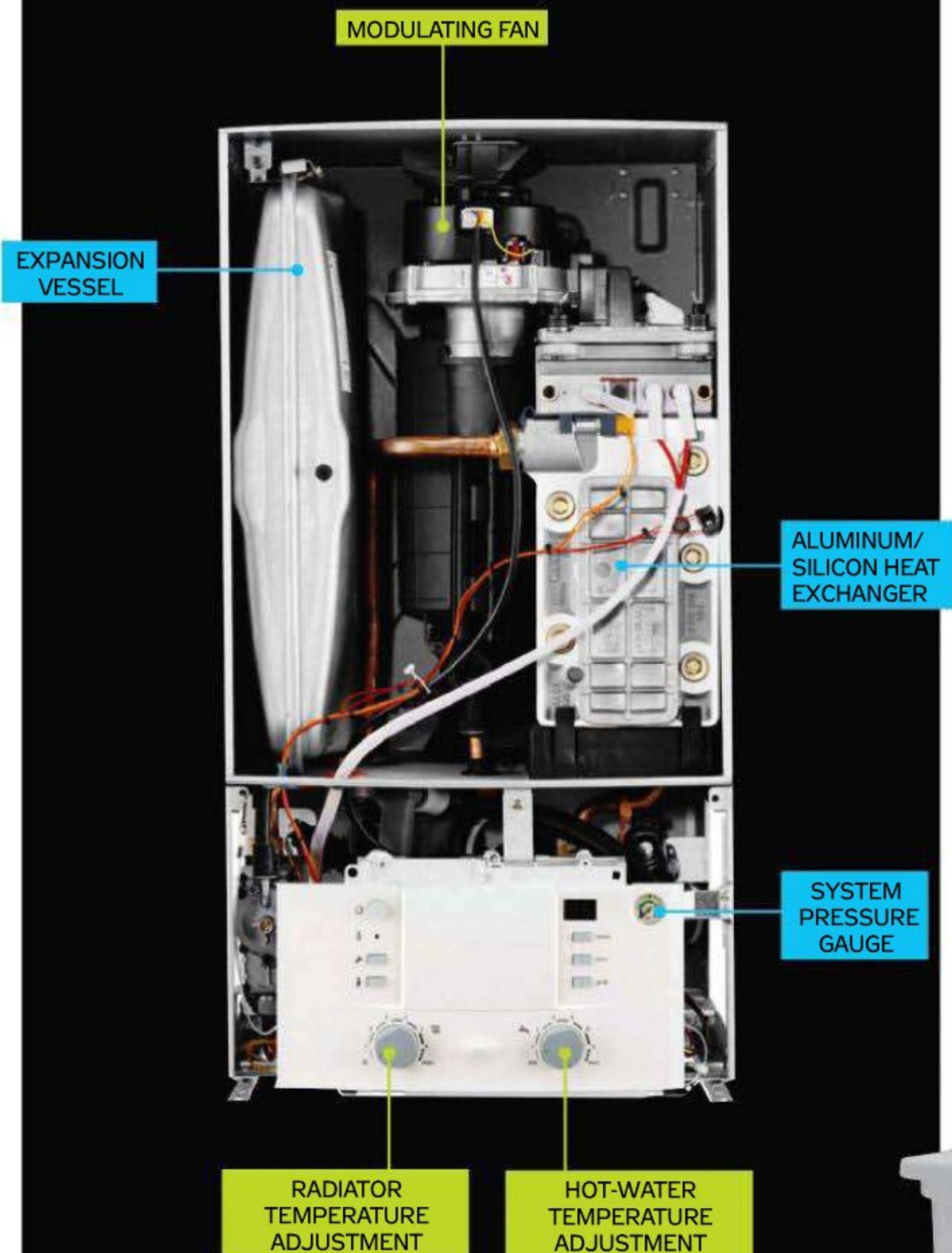


Boiler Extraordinaire → All due respect to the furnace, but spending a winter buffeted by hot, dry air doesn't compare to lolling in the cozy comfort of hydronic radiant heat. Those mittens drying on the iron radiator? Wonderful! Now there's a stellar new option for feeding those heating units and more. **Bosch Greenstar Boilers (\$4390 for a 100K-Btu unit)** can burn up to 98.7 percent of the natural gas or propane pumped in. This is incomparable efficiency for a combination boiler and water heater, which supplies H₂O to radiators and showers. A modulating fan adjusts air intake to optimize fuel use. An aluminum/silicon heat exchanger's 50-plus fins transmit heat better than all-aluminum units. The machine heats up when the weather cools, thanks to an outdoor weather monitor. And an expansion vessel allows the system to churn up to 120 liters of water—perfect for stately radiators big enough for the whole family's mittens.

Two to Tailgate



→ While developing **Stanley's Nineteen13 Carbonated Drink Bottle (\$28)**, senior industrial designer Tyler Gilbert staked out Big Gulpers at a local soda fountain until he devised an ideal vessel to prolong the fizz. Domed interior sides resist pressure buildup, and a firm lid leash keeps the cap from smacking you in the face. The cola could stay a bit colder, but that's where the **Yeti Roadie 20 (\$199)** comes in. Its 2.5-inch polystyrene insulation dwarfs typical inch-thick cooler walls. Bungee-style rubber fasteners shut the lid tight; a hefty gasket seals the deal. A padlock port stymies bears and thieves. And after a 23.5-hour test, we still had ice. Cheers.



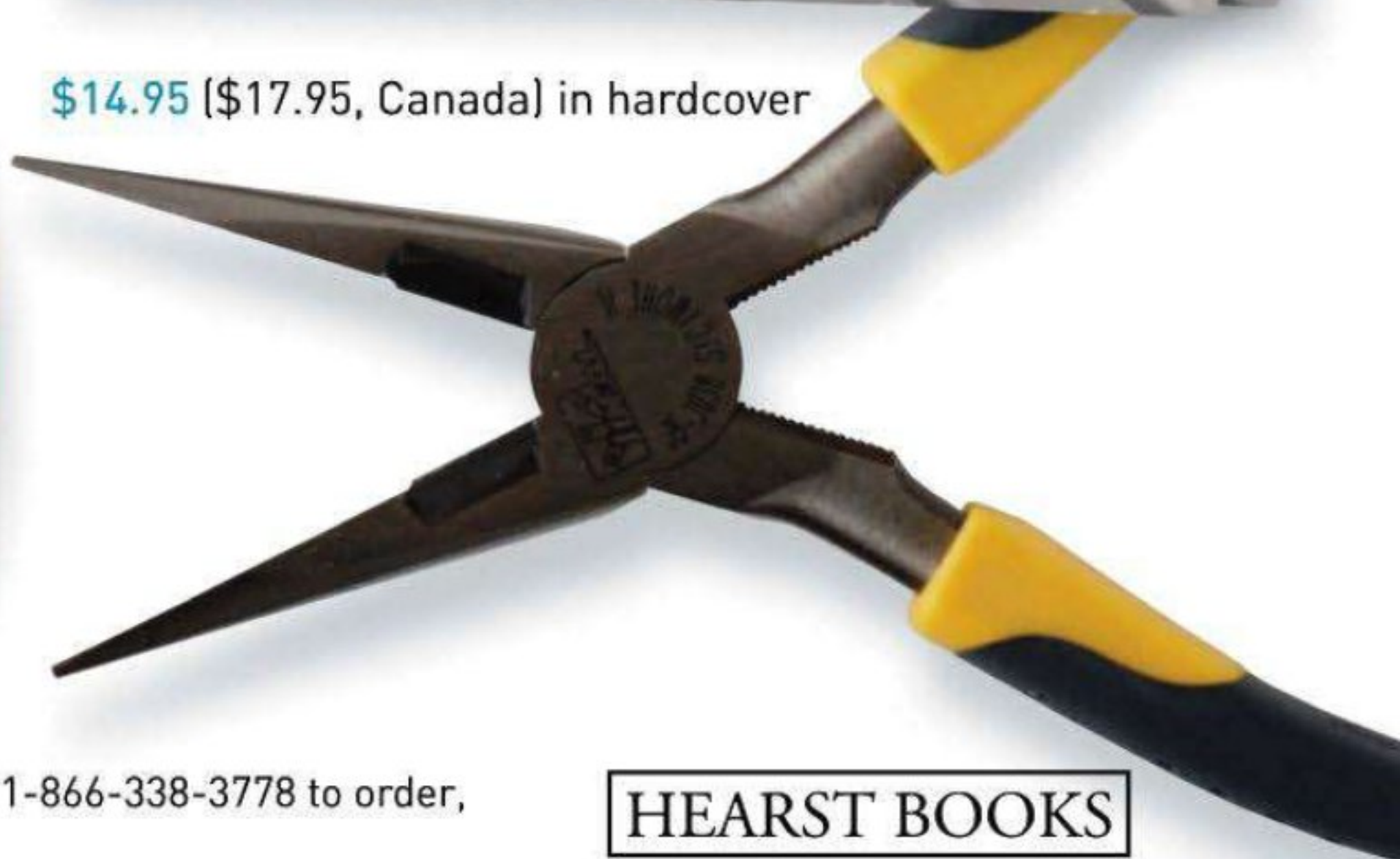
WHAT'S IN YOUR TOOLBOX?

When something needs to get fixed—whether a leaky faucet or faulty electrical circuit—you're the kind of man who rolls up his sleeves and takes care of business. But to do the job right, you need the right tools.

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Saw Swinger

→ Not too many power tools combine the precision of a jigsaw and the versatility of a reciprocating saw, but then again, few pair those qualities in as many ways as the **Rockwell Trans4mer (\$120)** does. For instance, the 3-inch blade can pivot 90 degrees until it's in line with the handle, like a reciprocating saw—and that's just one of the hybrid's six cutting positions. Considering the whole package almost fits in your palm, the tool is surprisingly capable: It cuts up to 2-inch-thick wood, $\frac{5}{32}$ -inch steel sheet and $1\frac{3}{4}$ -inch-diameter PVC pipe. The 2400-rpm stroke won't do demolition like a Sawzall, but it can sneak into a stud bay just the same. Use it to notch framing, trim 12-gauge sheet metal, alter a shop shelf and more.



Debut Socket

→ Fed up with spending Saturday projects searching for a lost socket, civil engineer E.J. Kim invented a universal head he calls the **Go-2 Socket (\$15)**, a tool that also grips and extracts rounded, damaged bolts. A fat machine screw through the side of the socket cranks down on a flat facet, wedging the head into a V-shaped nook. The socket should then jolt the bolt free. It's a promising concept, but in our testing, we wished the threads were finer for more precise adjustment. But, hey, it's Kim's first tool on the market—nice start!

Chain Breaker →

Snipping link after link of No. 135 zinc-plated chain with the **Knipex CoBolt Compact Bolt Cutters (\$78)** took less effort than squeezing a pair of Vise-Grips. Credit the flared recess near the pliers' pivot point, which bites and holds links, nails, bolts, rivets or hanging rods for drop ceilings while the user musters up a measly 190 newtons of fist force. An offset-lever action multiplies that grip by a factor of 20. Up against induction-hardened cutting edges rated on the Rockwell scale at 64 HRC, shanks don't stand a chance.





✓Yes



✓Yes



✓Yes



xNo



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The Tech-O-Meter

→ New gadgets hit the market at such a fast pace that they can all become a blur. Here we present 11 items worth focusing on, for better or worse. *BY JOHN HERRMAN*

WINDOWS PHONE MANGO The first major update to Microsoft's smartphone is a giant leap forward at a make-or-break moment for Windows Phone: It can finally hold its own against iOS and Android, but is it too late? *(from \$200)*

WII U Nintendo's next console has a wireless, tablet-like controller. Demos look promising. If it's a hit, it could match the success of the Wii. If not, well, remember Sega? *(price not set)*

ULTRABOOKS The Samsung Series 9 is part of a new breed of thin, attractive, solid-state laptop PCs. Intel calls them Ultrabooks. With similar machines due from Asus and HP, the Ultrabook template is a clear look at the future of laptops. *(\$1150)*

PANASONIC TOUGHBOOK Just another Android tablet, but it can take a lickin'. *(price not set)*

NOKIA N9 Poor Nokia planned a new smartphone OS, MeeGo, and lovely hardware to go with it. Then Nokia switched to Microsoft Windows Phone and MeeGo was euthanized. The N9 may be the only MeeGo phone released. *DOA. (price not set)*

EARTHSHAKING

OLYMPUS PEN E-P3 SERIES The acronym is EVIL (electronic viewfinder with interchangeable lens), but Olympus's retro-style cameras are good. The family—the full-featured PEN E-P3, the smaller, cheaper E-PL3 and the silly-thin E-PM1—features improved sensors and image processing. All make a solid case against entry-level DSLRs. *(E-P3, \$900; others, price not set)*



MOTOROLA TRIUMPH An Android phone with a twist: It's on Virgin Mobile, contract-free. *(phone, \$300; plans from \$25/month)*

SONY VITA With the Vita—call it PSP, take three—Sony bets that console-quality graphics, a touchscreen and downloadable games will keep the smartphone gaming threat at bay. We'll see. *(\$250)*



SONY PLAYSTATION 3D DISPLAY A 3D gaming monitor with a minor but brilliant trick: The glasses show two players two different outputs. No split screen. But worth the price? *(\$500)*

KINGSTON WI-DRIVE The best way to add storage to an iPad is with this 16 GB wireless external drive. But it's not just the best way, it's the *only* way. *(\$130)*

BLACKBERRY 7 PHONES Once upon a time, "BlackBerry" meant "smartphone." The world has moved on. This new line is already disastrously outdated. *(est. from \$200)*

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New Cars

ICONOCLAST

2012 VOLKSWAGEN BEETLE + BASE PRICE \$18,995

It's not easy to remake an icon. And yet the 1998 New Beetle was a massive hit. So what to do for an encore? Lose the Beetle's cutesy image and replace it with a little machismo—and substance.

Volkswagen's designers brought forward the original Beetle's flatter, chopped roofline for a hunkered, more serious look. The \$18,995 Beetle will come with a standard 170-hp inline-five model or an optional 200-hp turbo four-banger for \$23,395. Both will be mated to VW's DSG or manual transmissions. The new car rides on a shortened version of the VW Jetta's chassis. But only the Turbo wears an independent rear suspension. Slide into the Beetle's

front seat and you'll notice retro touches such as the second Kaeferfach glovebox. On the roads surrounding Berlin, the Beetle Turbo was completely docile and rode smoothly despite the big, 19-inch tires. Dig deep into the throttle to pass another car and there is serious lag time before something happens. Select the DSG's Sport mode—problem solved. The Beetle snaps to attention and is happy motoring at a quick clip. Although the Beetle Turbo is a rung or two below the GTI in terms of sportiness, bending it into a series of curves certainly is fun. Unfortunately for diesel fans, a TDI model won't be on sale until the spring of 2012. — BEN STEWART



New Cars TEST DRIVES

 ○ SAAB STORY
2012
Saab 9-4X2012
Harley-Davidson CVO Road Glide Custom2012
Range Rover Evoque

The 9-4X is Saab's first all-new model in years and a legacy of the period when GM owned the Swedish brand. Thus, the 9-4X (\$34,205) rides on the same chassis as the Cadillac SRX and borrows a couple of GM V6 engines. That Caddy hardware pays dividends—the 9-4X has the same creamy refinement as the SRX. We spent three days cruising around metro Detroit in a top-of-the-line Aero and found the 300-hp turbo engine easily up to the task of motivating the 2-ton wagon. The Bose surround-sound system kicked hard, whether we were listening to Iggy and the Stooges (hey, this was Detroit) or soothing classical. We dig the 9-4X's huge, 20-inch wheels and the novelty of the marque. More than one fellow motorist felt compelled to roll down a window and ask, "Hey, what is that?" Yup, it's a Saab, only prettier than the brand's utilitarian reputation would suggest. — JOE BARGMANN

○ HOG HEAVEN

For 2012, the Road Glide Custom is the meanest bike spawned by Harley-Davidson's Custom Vehicle Operations (CVO). It packs a whopping 110-cubic-inch twin-cam V-twin motor that generates a Metzeler-melting 122 lb-ft of torque, thanks in part to the high-flowing Heavy Breather conical air-intake system. At 800 pounds, the Glide is a big machine. Yet this beast will hit triple-digit speeds faster than any big Harley we've ridden. And it's reasonably easy to bend into corners without scraping the floorboards. Each bike gets a custom paint job and other sweet modifications. The downside? The \$30,699 price tag. Start saving. — BEN STEWART

 GOOD ROVER

The Evoque, Land Rover's long-awaited baby Range Rover, finally hits the streets this October. The gorgeous proportions and jewel-like details are faithful to the 2008 Detroit auto show concept, the LRX, and its driving demeanor backs up its good looks. With no transfer box or low ratio, this is an all-weather SUV rather than an off-road mud plugger, but with a Haldex clutched 4x4 system, there's enough traction and ride height for peace of mind in the snow states. A 237-hp 251-lb-ft 2.0-liter four-cylinder punches well above its weight, and the six-speed automatic performs admirably. With great looks, positive handling and a very fine interior, the Evoque effectively stretches the Range Rover lineup. The new Audi Q3 will undercut Evoque's price (\$43,995), but this mini Range is the more desirable object. — ANDREW ENGLISH

I EXPANSIONISM

Mitsubishi's EV program is not well-known in the U.S., especially when compared with the highly hyped Nissan Leaf and Chevy Volt. But back in Japan, Mitsubishi has offered a small, battery-powered runabout, the i-MiEV, since 2009. Next January, a larger version of the car will be available stateside. The new model will be known plainly and without apologies to Apple's Mr. Jobs as the i. Not the i-MiEV, iEV or the iCar—just i. Intended for urban commuters, the North American i seats four. It's roomier and more attractive than the skinny Japanese version, but equally competent—and dull—to drive. The 66-hp AC motor gets juice from 88 lithium-ion battery cells integrated in the floor. Zero to 60 mph arrives in about 15 seconds, with 80 or 81 mph following eventually if you keep the amp pedal mashed long enough. While the comfortable and understeering i won't spark a fire in the hearts of driving enthusiasts, its efficiency is impressive: 126 mpge (miles per gallon gasoline equivalent) city, 99 mpge highway. The \$27,990 price undercuts Nissan's Leaf by more than \$5000; whether that's enough to make you consider living with a skimpy 62-mile range is up to you. — REX ROY



2012
Mitsubishi i

A GIANT OF A KILLER

The 2012 Dodge Charger SRT8, one of four vehicles offered by Chrysler's Street and Racing Technology in-house tuning brand, is a great alternative if you really want a Mercedes-Benz AMG E- or S-Class but don't happen to have 100 large. For about \$47,000, this menacing rear-wheel-drive sedan easily rips off mid-4-second 0-to-60 runs, tops out at 175 mph and has enormous slotted Brembo brakes. Power comes from Chrysler's signature Hemi-head engine, which displaces 6.4 liters and puts out 470 hp with 470 lb-ft of torque. The heavy-duty, five-speed automatic features paddle shifters and good shifting algorithms, but it's missing at least two cogs compared with competing high-performance sedans. Interior niceties include comfortable leather buckets and a bright 8.4-inch LCD with a multifunction performance computer. The Charger is surprisingly tossable for a 4400-pound car—if you overcook a corner or botch an apex, the forgiving chassis saves you. The two-stage electronic stability control offers a third position, and when the dash telltale warns it's off, it really is. — R.R.



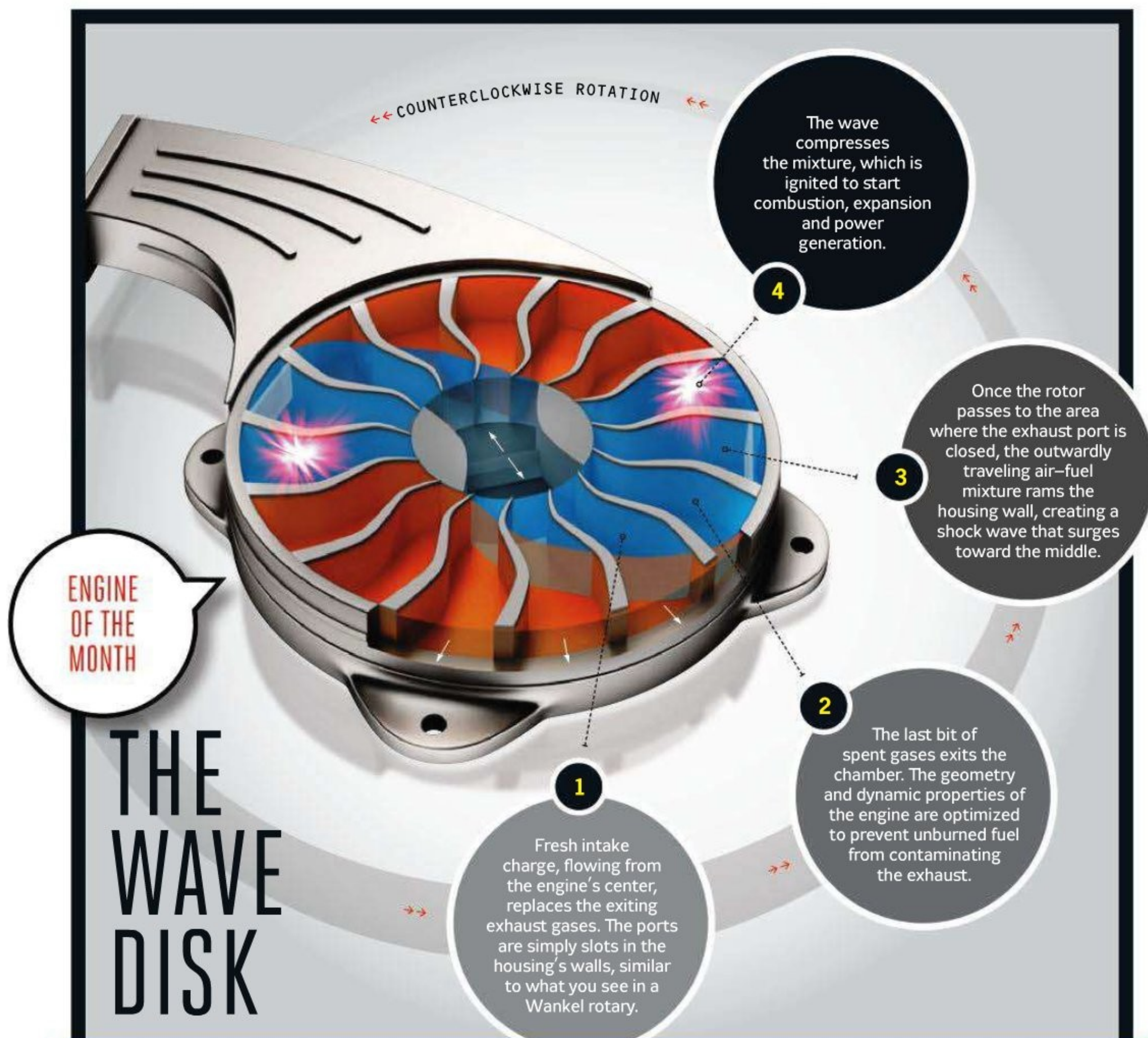
2012
Dodge Charger SRT8

ONE ROOMY RIDE

At \$10,990, the 2012 Nissan Versa sedan is a heck of a bargain, but we wouldn't characterize it as a steal. We'd say that any prudent shopper wanting the most interior room for the money ought to compare it with cars such as the Hyundai Accent, Ford Fiesta, Honda Fit and Toyota Corolla. The Versa drives fine. All of the responses are predictable, if very light (especially the steering), and wind noise at highway speeds is noticeable. Its placid ride is comfortable, even when the road is not. A lot of midsize luxo-sedans can't match its impressive back-seat room, including the 2011 Benz E-Class. Not that you will ever mistake this interior for that car's. The grade of fabrics, the feel of the plastics are all strictly T.G.I. Friday's, not even Panera. — MICHAEL FRANK



2012
Nissan Versa



MICHIGAN STATE UNIVERSITY'S WAVE DISK ENGINE COMPRESSES AIR AND FUEL BY USING INTERNAL SHOCK WAVES.

Michigan State University researchers, headed by professor Norbert Müller, have developed an ingenious Wave Disk internal combustion engine. The engine is flat, about the size of a saucepan, with a 15-blade rotor, and it relies on shock waves to compress the fuel and air mixture. The intake charge enters the area between the blades through ports at the hub, while the exhaust exits through ducts at the rotor's outer edge. The cycle works like this: Starting from the center of the disk and radiating outward, the incoming intake charge replaces spent gases as the rotor spins. When the chambers between the blades pass to the area where both the intake and exhaust ports are closed, the outwardly flowing intake gases

slam against the housing wall. This creates a shock wave, which travels back toward the center, compressing the air-fuel mixture. The fuel is ignited and the gases expand, pushing the rotor counterclockwise. The engine operates at a constant rpm, and the geometry of the parts is optimized to reduce emissions. When used as a backup generator in a hybrid car, the engine could potentially increase efficiency by more than three times compared with a piston-engined vehicle—thanks in equal parts to the engine's cycle and its simple, lightweight design. MSU recently received a \$2.5 million grant to continue research, and Müller plans to have a 34-hp unit running this year. — LARRY WEBSTER




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Ford, like almost every other automaker, is offering smaller turbo four-cylinder engines as alternatives to the ubiquitous V6. New tech means these thriftier engines suffer few downsides.

While buyers generally don't care what size engine is under the hood, they want to feel a reassuring shove when they hit the gas. So technology has become the necessary replacement for big cubes and cylinder count.

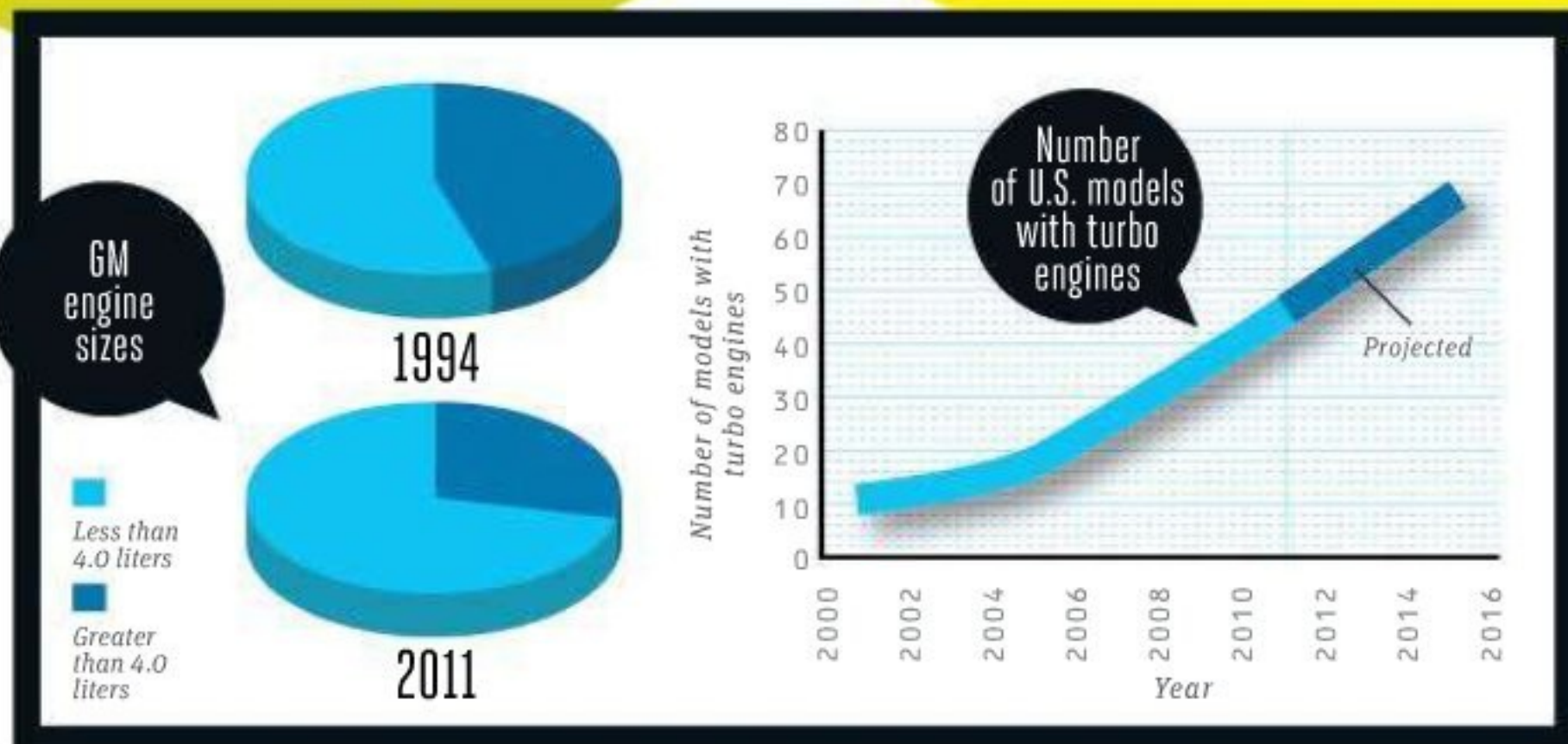
Nowadays, even low-priced cars have high-tech engine systems such as direct fuel injection and variable valve lift. Those features, however, offer only modest power and efficiency gains. To really make a small engine perform, you need some type of boosting system.

One answer is turbochargers, the exhaust-driven compressors that stuff more air into the engine and increase power. Turbos are not new (the first appeared around 1905 and were briefly popular in cars in the 1980s), but better materials and electronic controls have mitigated disadvantages such as turbo lag, the brief delay between pressing the gas and the turbo kicking in.

Consider Ford's upcoming 2.0-liter EcoBoost inline four. This engine will produce 240 hp and will be available alongside the 290-hp 3.5-liter V6 in the Explorer. The turbo motor will improve highway fuel economy by 12 percent, to around 28 mpg. How? When the engine is lightly loaded and the exhaust flow is minimal, the turbo provides little or no boost. But floor the throttle and the turbo awakens, pumping in extra air—fuel mixture to provide a second wind. It's a little engine that acts big on demand.

Another option is electric boost, such as GM's eAssist system, which is standard on Buick's LaCrosse. This "mild" hybrid setup uses a 15-hp starter/generator in place of the alternator to assist the 2.4-liter four-cylinder, boosting fuel economy about 20 percent, to 25/36, with power equal to a small V6 (182 hp). And the mild hybrid system is simple and relatively cost-effective.

Expense is an issue. Extra turbo and electric hardware can inflate sticker prices by anywhere from \$500 to a couple of grand. Technology is never free, but in this case, customers will likely save enough at the pump to offset the difference. **PM**



THE REPLACEMENT FOR DISPLACEMENT

IN A MOVE TO SAVE FUEL, THE MOTTO "THERE'S NO REPLACEMENT FOR DISPLACEMENT" HAS BEEN CAST ASIDE. NOW THERE'S A NEW RELIGION IN THE HALLS OF THE WORLD'S AUTOMAKERS: ENGINE DOWNSIZING. **BY REX ROY**

ENGINE SIZE IS DEFINED BY DISPLACEMENT, the combined volume of the cylinders expressed in either cubic inches (350 cubic inches) or the metric equivalent (5.7 liters). For years, carmakers satisfied market demands for more power simply by making larger-displacement—and thirstier—engines. But thanks to the first major tightening of Corporate Average Fuel Economy (CAFE) regulations in decades and customer preference for higher efficiency, the trend now is for smaller, not bigger, engines.

Since 1994, the percentage of GM's engines under 4.0 liters has grown from 55 to 71. Also in 1994, GM's smallest engine was a 2.2-liter four. Today, the automaker offers three motors under 2.0 liters.

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I used to be more active. I used to run, play basketball, tennis, football... I was more than a weekend warrior. I woke up every day filled with life! But now, in my late 30's, I spend most of my day in the office or sacked out in front of the TV. I rarely get to the gym – not that I don't like working out, it's the nagging pain in my knees and ankles. Low energy and laziness has got me down. My energy has fizzled and I'm embarrassed to admit that I've grown a spare tire (I'm sure it's hurting my love life). Nowadays I rarely walk. For some reason it's just harder now. Gravity has done a job on me.



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I put them on and all I could say was, "WOW!" In minutes I was out the door. I was invincible; tireless in my new Gravity Defyer shoes. It was as if my legs had been replaced with super-powered bionics. What the doctor promised was all correct. No more knee pain. I started to lose weight. At last, I was pain free and filled with energy! I was back in the game. Gravity had no power over me!

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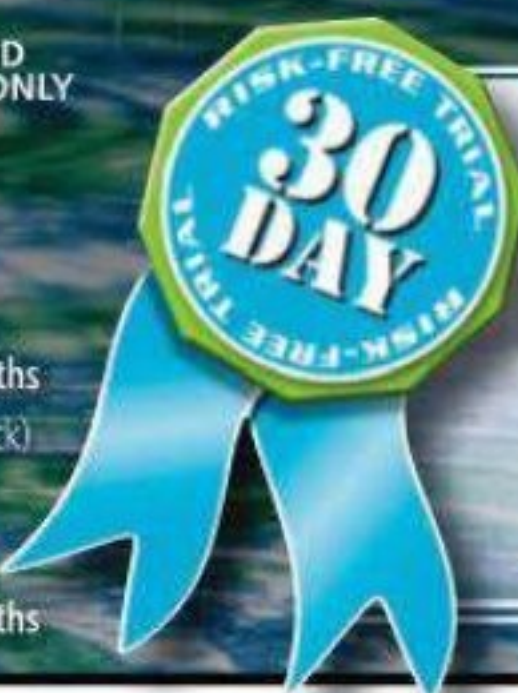
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Building the Perfect Jeep

> BY JOE PAPPALARDO
> ILLUSTRATIONS BY RAZVAN MAFTEI

BY COMBINING IDEAS AND TECH FROM INDUSTRY EXPERTS, OUR EDITORS CREATE THE IDEAL REPLACEMENT FOR ARMY AND MARINE CORPS HUMVEES—THE POPULAR MECHANICS LIGHT TACTICAL VEHICLE (PMLTV).

Common Remotely Operated Weapon Station (CROWS) allows troops to fire weapons from inside the vehicle by using a joystick.

Developed by Kongsberg

Gunfire detection system can locate threats from the acoustic signature of firearms.

Developed by Raytheon

"Sweating" armor emits water through microscopic pores in the vehicle's skin to reduce the thermal signature.

Developed by BAE Systems

Sensors enable the PMLTV to operate as an unmanned ground vehicle. Modes include follow-the-leader as well as waypoint and autonomous navigation.

Developed by U.S. Army; DARPA

T

THE PENTAGON IS HAVING A DEVILISHLY HARD TIME building a light tactical vehicle to replace the Humvee, which was introduced in the early 1980s to haul gear, ferry troops and conduct patrols. Contractors are vying to produce the next-generation all-purpose vehicle, called the Joint Light Tactical Vehicle (JLTV), for the Army and the Marine Corps. But with \$300 million already invested—and at least \$580 million more in projected development costs through 2015—the only options thus far have been expensive, overweight prototypes.

In February the Army's product manager of the JLTV program revealed to attendees of a National Defense Industrial Association wheeled-vehicle conference that each of the 21 JLTV designs submitted by contractors was as much as 1000 pounds too heavy. This degrades the vehicles' performance and, since JLTVs will be built to be carried by specific helicopters and fixed-wing aircraft, restricts their deployment. The cost is also rising. Replacing steel with lighter composites and metal alloys drives up the price; the JLTV options are already topping the \$300,000 goal set by the Pentagon. Existing Humvees cost \$75,000; with an extra armor kit, the price is around \$200,000.

Not willing to sit by while the defense industry that created the Jeep flounders, PM took action. We called on the nation's best military-vehicle designers to help us create the PMLTV, a rugged, menacing piece of machinery, if we do say so ourselves.

REQUIREMENTS

Curb weight:
13,600 lb

Payload: 3500 lb

Air-transportable:
C-130 fixed-wing,
CH-47 and CH-53
helicopters

Carrying capacity:
Four crew

Armor: Bolt-on
protection option
for higher-risk
operations



1 BLAST CHIMNEY

In order to save the weight of armor, the PMLTV instead uses a flue to channel energy from an explosion through the center of the vehicle, guiding the damaging blast away from the occupants. The downward thrust produced by the blast rushing through the chimney also helps keep the PMLTV from flipping. Maryland-based Hardwire LLC is pitching the chimneys to the military; the Pentagon is blast-testing the tech now.

2 DIESEL-ELECTRIC POWERTRAIN

The PMLTV's diesel engine is connected to an electrical generator, which creates power for a traction motor driving each axle. This eliminates the need for a transmission and a conventional drivetrain, creating more room under the crew compartment for 360 degrees of armor. For a scout vehicle operating far ahead of the front lines, the option of switching to nearly silent propulsion is very appealing. We like vehicle manufacturer Oshkosh's ProPulse system, a 450-hp engine that can also export enough power to run a field hospital.

3 FORD F-450 FRAME

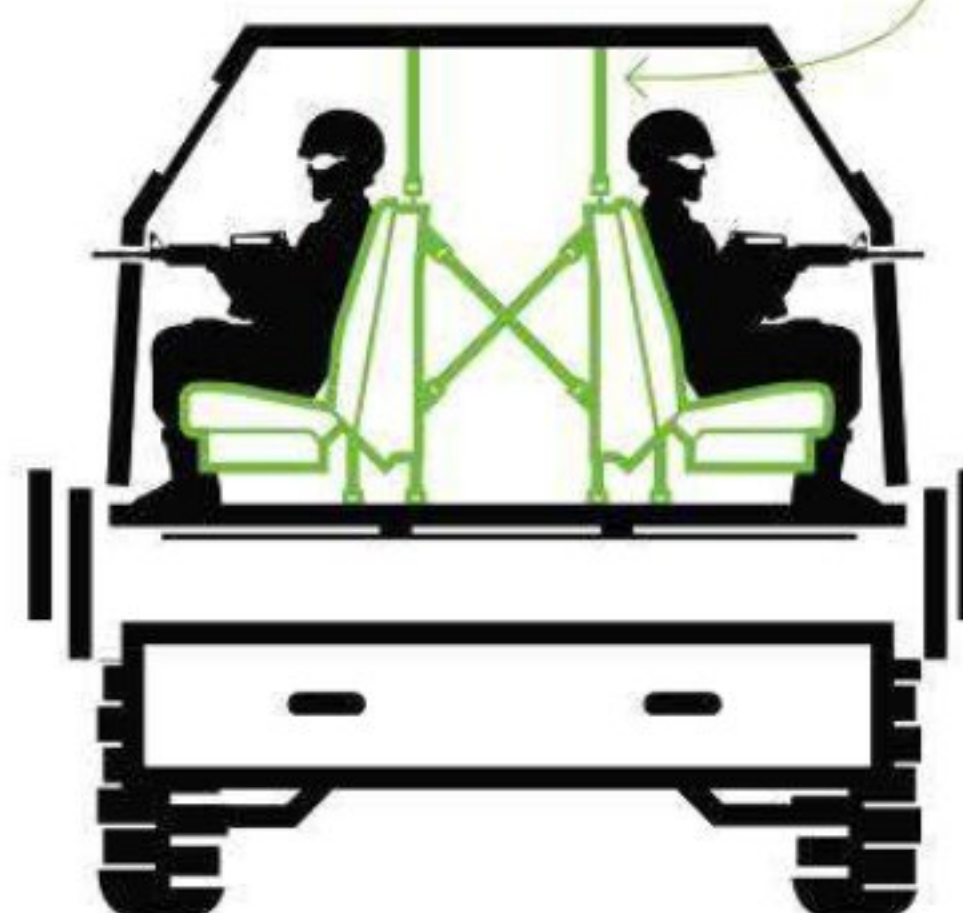
Most military-vehicle companies prefer the flexibility offered by their homegrown chassis, but purchasing an available and trusted vehicle frame from a commercial production line can save hundreds of millions of dollars. In 2005 vehicle designer Scott Badenoch and the Georgia Tech Research Institute developed an armored patrol vehicle using a Ford F-350 truck frame; we opted for the wider F-450. At about 5000 pounds, the F-450 chassis is heavy, but it can handle thousands of pounds of payload without going over the specified 13,600-pound curb-weight limit.

4 TAK-4 SUSPENSION

It's hard to build an active suspension system that is both agile and tough enough to handle on- and off-road conditions. The F-450 suspension is certainly not up to the task, so the PMLTV adopts the new version of TAK-4, made by Oshkosh. This independent suspension system uses high-pressure gas to raise and lower the vehicle 20 inches with the flick of a switch on the front-seat dashboard. The government is now testing the new TAK-4, says Chris Yakes, Oshkosh's vice president of advanced products.

5 CREW COMPARTMENT

Many new armored vehicles have steering wheels in the center of the dash, which allows greater visibility. The layout of the ballistic-resistant windows provides a better field of vision. Inside, a cage of tubular steel protects occupants during rollovers, and seats are suspended to halt the transmission of explosive shock waves to occupants.





Invasive Species? If You Can't Beat 'Em, Eat 'Em

> BY GLENN HARLAN REYNOLDS
> ILLUSTRATIONS BY COLWYN THOMAS

IN THE 21ST CENTURY WE FACE ALL SORTS OF PROBLEMS: environmental, economic, political and military. But sometimes a little creative thinking can turn a problem into an opportunity.

One big problem—brought on by the expansion in global trade and travel that transplants people and other creatures willy-nilly around the world—is the rise in invasive species. These species, from Asian carp to kudzu, may fit nicely in their original ecological niches, but transplanted to a new place where they have no established predators, they can explode in number, crowding out valuable critters and plants and ruining things for people.

Lots of responses have been tried, such as hunting, spraying or bringing in new predators to exterminate the newcomers. Sometimes the efforts work, but often they don't. Occasionally they make matters worse by adding a new problem species.

But what if instead of importing predators, we became the predators? Hungry humans wiped out the passenger pigeon and turned Chilean sea bass into a scarce commodity. Can we do the same with unwanted intruders? That's what dive masters and

LIONFISH CAN DESTROY NATIVE REEF SPECIES. A GOOD FISHING SPEAR CAN HELP.

underwater explorers are trying to do with one of the Western Hemisphere's nastiest invaders, the lionfish.

Lionfish are native to the Indian Ocean and South Pacific. They first appeared in noticeable numbers in Caribbean and Florida waters around 2000 and have expanded rapidly since. They occupy valuable reef niches and can compete other fish out of existence.

Probably because lionfish look strange and respond aggressively when approached—flaring their poi-

sonous spines to look bigger and fiercer—potential predators leave them alone. They don't look like familiar food, and they do look like trouble.

Dive masters throughout the Caribbean are trying to remedy this by spearing lionfish and feeding them to sharks and groupers, to teach them something important about lionfish that isn't apparent to the naked (fish) eye: They're delicious.

It may be starting to work. On a recent trip to the Cayman Islands, I accompanied dive operators Nat Robb and Art Hintze of Indepth Watersports on a number of lionfish hunts. Using a three-pronged spear, they impaled lionfish, snipped off the spines and fed them to groupers. On many occasions, the groupers snatched them off the spear and gulped them down before the spines were even removed—the spines can inflict a painful sting on people, but these fish didn't seem to mind—demonstrating that they'd learned from prior observation that lionfish make a tasty snack. In fact, at one dive site, groupers began clustering and following us as soon as they saw the spear, as though it were an underwater dinner bell.

Will the groupers start hunting lionfish on their own? Let's hope so. Even fish are capable of learning, when there's a meal to be had.

But people learn faster. Back on the boat, I snacked on lionfish sashimi prepared carpaccio-style with lime juice, olive oil and capers—and it was very good. Cooked, the flesh tastes like something between Chilean sea bass and lobster. It's good grilled, fried or jerked. (Lionfish tails even resemble lobster tails.)

Restaurants on the Caymans are beginning to serve lionfish, and if the trend catches on, human gourmets may do for lionfish what they've already done for numerous other edible marine creatures, generating suf-



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P M

THINKING AHEAD /// INVASIVE SPECIES

ficient demand to drive the species' numbers way, way down.

Some people are taking this approach further. Jackson Landers, author of the Locavore Hunter blog, is a big fan of eating lionfish, saying, "It's like Chilean sea bass without the guilt." Landers has also feasted on invading European green crabs, nutria, Asian carp—he's working with Louisiana chef Philippe Parola on a plan to turn that creature into delicious mass-marketed meals—and even armadillo. (Fears of leprosy, he says, are grossly exaggerated.)

I asked Landers if it was important to get restaurants involved in serving invasive species, and he said yes: Putting the critters on menus lends "a lot of legitimacy" to the idea of them as food. Stock grocery shelves with them and instead of an expensive eradication program, we've got a self-financing method of pest control.

But building a market is not essential, and Landers encourages a DIY approach. "Even on a locavore hunting level we can make a difference as individuals," he says. "If you have a patch of reef that you dive once a week

and spear every lionfish you see, then that is going to be a little oasis where the cleaner wrasse, a species threatened by lionfish, can survive, and fish from hundreds of miles away can come to have their parasites removed. That reef might be surrounded by a wasteland of lionfish, but as long as someone is taking personal responsibility for his reef, then you've got a place where some of these endangered species can survive."

The same thing works on dry ground, Landers says: Individuals hunting for their tables wiped out invading wild boar in parts of West Virginia. And got tasty meals to boot.

I think there's a lot to this approach. Too often, preserving the environment is seen as involving a great deal of sacrifice. But sometimes it can be as rewarding as eating lionfish sashimi. Which, take it from me, requires no personal sacrifice at all.

Meanwhile, I wonder if there isn't a larger lesson here. Life is full of problems, but often the solution isn't to attack them head-on, with big programs, but to find ways to let markets and individuals solve them on their own. Are there other problems out there that, with the right approach, could be turned into the equivalent of appetizing snacks? Perhaps we should look. **PM**

Lionfish Carpaccio



Glenn Reynolds is **POPULAR MECHANICS'** resident contrarian, a longtime scuba diver and an enthusiastic omnivore. His weapons in the fight against invasive species: lime, hot sauce and a cold beer.

INGREDIENTS

3 large limes
3 tablespoons sugar
Liberal amount of olive oil
Salt and pepper to taste
As many capers as you like
Dash of Tabasco or other
hot sauce (optional)
Lionfish

DIRECTIONS

Squeeze the limes and mix the juice with all the other ingredients except the fish. This mix will keep in the fridge, although the olive oil does go a little cloudy once refrigerated. With *extreme* care de-spine and fillet the lionfish. Slice the fillets as thinly as possible. Drizzle the sauce over the meat.

Serve with crusty French bread.

Recipe courtesy of dive operator Art Hintze of Indepth Watersports, Cayman Islands

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FOUNDATION CRACK. THIS CALLS FOR GREAT STUFF.™
And maybe a pirate get-up. Arrr.



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WHAT WENT WRONG

EXPLOSION IN SAN BRUNO

BY JEREMY REPANICH

LOCATION: SAN BRUNO, CALIF.
EVENT: GAS PIPELINE RUPTURE
DATE: SEPT. 9, 2010

It happened without warning. On the evening of Sept. 9, 2010, a natural gas pipeline operated by Pacific Gas and Electric (PG&E) in the San Francisco suburb of San Bruno ruptured, then exploded. The blast launched a 28-foot section of the buried pipe 100 feet, leaving behind a 26 x 72-foot crater. Leaking natural gas fueled a massive blaze. Eight people died; 108 homes were damaged or destroyed. The National Transportation Safety Board (NTSB) determined that the blast occurred after the power supply to a valve 35 miles away malfunctioned during maintenance and steadily increased pressure in the line, blowing apart a weakened section. But one factor alone didn't cause the disaster; instead, it was the result of a chain of missteps, from installation to maintenance. "When you start to

pile up the multiple breakdowns in quality control," says Robert Bea, an engineering professor at the University of California, Berkeley, and an expert on large-scale engineering disasters, "you see this thing was incubating from the day they put it into the ground until it blew up."

CRESTMoor CANYON, SAN BRUNO, CALIF.

Damage zone
(about 15 acres)

Unaffected
Damaged
Destroyed

Ruptured pipe landing site
(100 feet from crater)

Blast crater
(26 x 72 feet)

Direction of gas flow

TIMELINE OF THE DISASTER

1956

PG&E installs a 30-inch-diameter transmission pipeline. Crews weld the exterior of a 28-foot-long section's lengthwise seam but neglect to weld the interior. To navigate uneven terrain, workers fuse short sections on-site, creating severe bends in the 47-mile-long pipeline that later prevent the use of inspection robots ("pigs").

EARLY '90S

PG&E's head of information and records management alerts company officials that pipeline maps are out of date and testing records are missing. Failure to act would be "costly to PG&E... it may be difficult to defend the nonexistence of this data." PG&E ignores the memos; no action is taken on the pipeline.

1998

While moving paper files to a computerized system, PG&E updates its records—and includes an error made in 1977. Staff lacking pipeline expertise had reviewed vouchers from the accounting department instead of notes by engineers who installed the line. They assumed a voucher marked SML referred to seamless pipe, when it actually meant seamed pipe.

2003

Starting in 2003, PG&E exploits what it thinks is a regulatory loophole: It can avoid costly inspections by spiking the pressure in some lines once every five years, then operate the pipelines at a lower psi than that maximum. "That's how PG&E interpreted it, but that was not the intent of the regulation," says Richard Kuprewicz, a pipeline-safety expert. With a seam like the one in San Bruno, he says, "spiking pressure is the last thing you want to do." But because of its cataloging error, PG&E didn't know the seam existed, which also explains why the utility never properly inspected its integrity.

2006

In an internal memo, PG&E engineer Chih-hung Lee writes that because the majority of damage comes in the first 30 seconds after a pipeline rupture, remote-control and automatic-shutoff valves have little or no effect on increasing human safety or protecting property. In the event of an explosion, crews will travel to shutoff valves and manually cut the gas.

2008

PG&E once again spikes the pressure in the pipeline, further weakening the seam with the faulty weld.

ILLUSTRATIONS BY PLAYLAB



Eight people died in a blaze that raged after a natural gas pipeline explosion in San Bruno, Calif.

↓ AFTERMATH

Shortly after the San Bruno explosion, the NTSB urged all gas companies to verify records on old pipe. At a hearing this past March, PG&E's Lee conceded that the fire caused by the gas leak could have been controlled much sooner if the automatic shut-off valves had been installed. And in June, the company released documents that showed a pattern of failed and defective welds in its network over many years. Currently, PG&E faces 74 civil lawsuits, and the Department of Justice has opened a criminal investigation.

↓ LESSONS

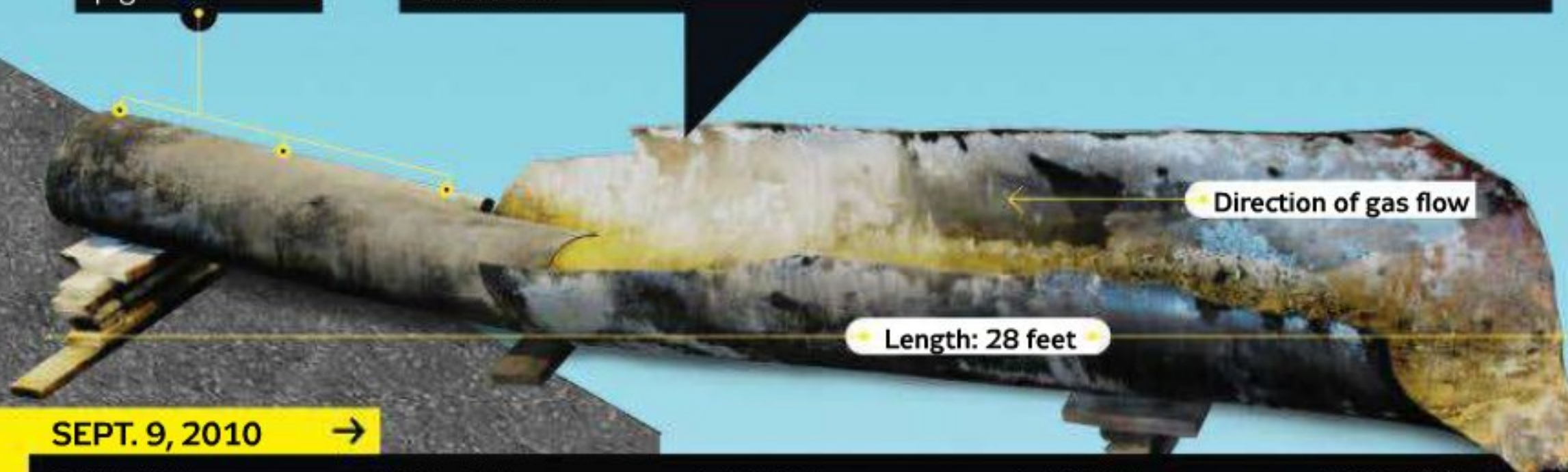
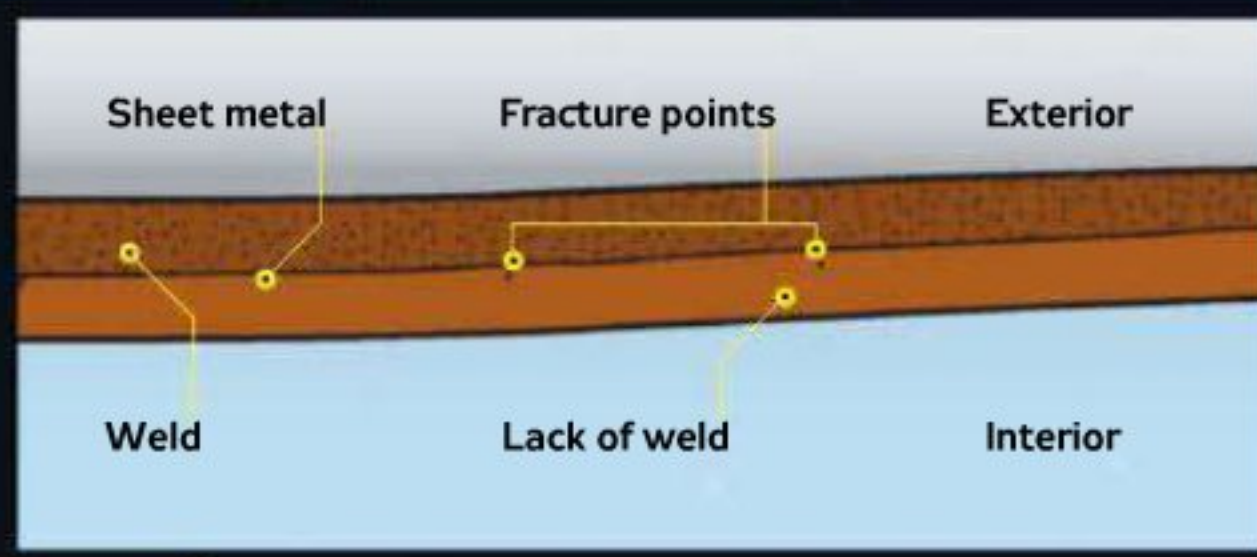
The San Bruno explosion highlights the dire state of the 2.4 million miles of natural gas pipelines in the U.S. In the past few years, pipes have failed in Virginia, Ohio and Minnesota, among other states. Between 2005 and 2010, natural gas pipeline incidents caused more than \$997 million in property damage—twice the costs incurred in the 15 years prior. At least 12 percent of the country's transmission lines are older than the San Bruno pipe; 36,000 miles of the lines that connect homes and businesses to the grid are made from fragile, leak-prone cast iron, some of which is more than a century old. UC Berkeley's Bea says more inspections are needed to avert future disasters, but most of the national transmission grid is not "piggable." Yet "pipelines are still the safest way to move [natural gas]," Kuprewicz, the pipeline-safety expert, says. "But this isn't soda pop you're playing with. It can kill in a heartbeat. You've got to maintain your network."

ANATOMY OF THE BLAST

A faulty weld and a pressure spike contributed to the deadly explosion of a natural gas pipeline in San Bruno. The NTSB released a photo of the pipe that shows it all started with a 2-inch breach.

Short lengths of sheet metal were fused together with **girth welds**. This created sharp turns that made the line impossible to inspect with pigs.

A cross section of the **rupture site** (right) shows that the $\frac{3}{8}$ -inch-thick pipe was welded only halfway through. Pressure-spiking tests weakened the seam.



SEPT. 9, 2010 →

3:05 PM

At PG&E's terminal in Milpitas, 35 miles southeast of San Bruno, workers begin to replace a power supply that failed in April 2010.

4:20 PM

Repair of an electrical panel in the Milpitas Terminal causes pressure transmitters and regulators to malfunction. Gas pressure surges along the entire 47-mile-long pipeline.

6:11 PM

In San Bruno, a 2-inch section of the seam ruptures, blowing open the pipe. The pressure ejects a 28-foot chunk of the line from the ground. The pipe lands 100 feet from the blast's epicenter, and the escaping gas is likely set aflame by a nearby home's pilot light.

6:16 PM

PG&E's control center in San Francisco sees a drastic drop in pipe pressure. Amid confusion, the dispatch center doesn't send crews trained to manually close the shutoff valves for half an hour.

7:30 PM

Approximately a mile from the blast site, a PG&E crew closes the upstream valve; 15 minutes later, a half-mile away, they close the downstream valve, allowing firefighters to bring the blaze under control.

• **Transmission pipeline**
(8 feet deep)

↓ PREVENTING DISASTER: Wider use of inspection devices and testing methods may prevent another incident like San Bruno's.

EXPLORER-II: A self-propelled robot that can navigate bends and obstructions, this inspection pig is equipped with cameras and a sensor that uses alternating current to examine the pipe wall.

EMAT: This electromagnetic acoustic transducer bounces a current off a magnetic field around the pipe, reflecting where cracks or flaws are present. Sensors detect the sound waves, and software constructs a map of the size and depth of flaws in the pipe.

HYDROTESTING: Operators fill an unpiggable pipe with water until it reaches maximum pressure, then hold that level to see if the line can withstand it. However, some experts criticize the tests for overstressing pipes and possibly making imperfections worse.

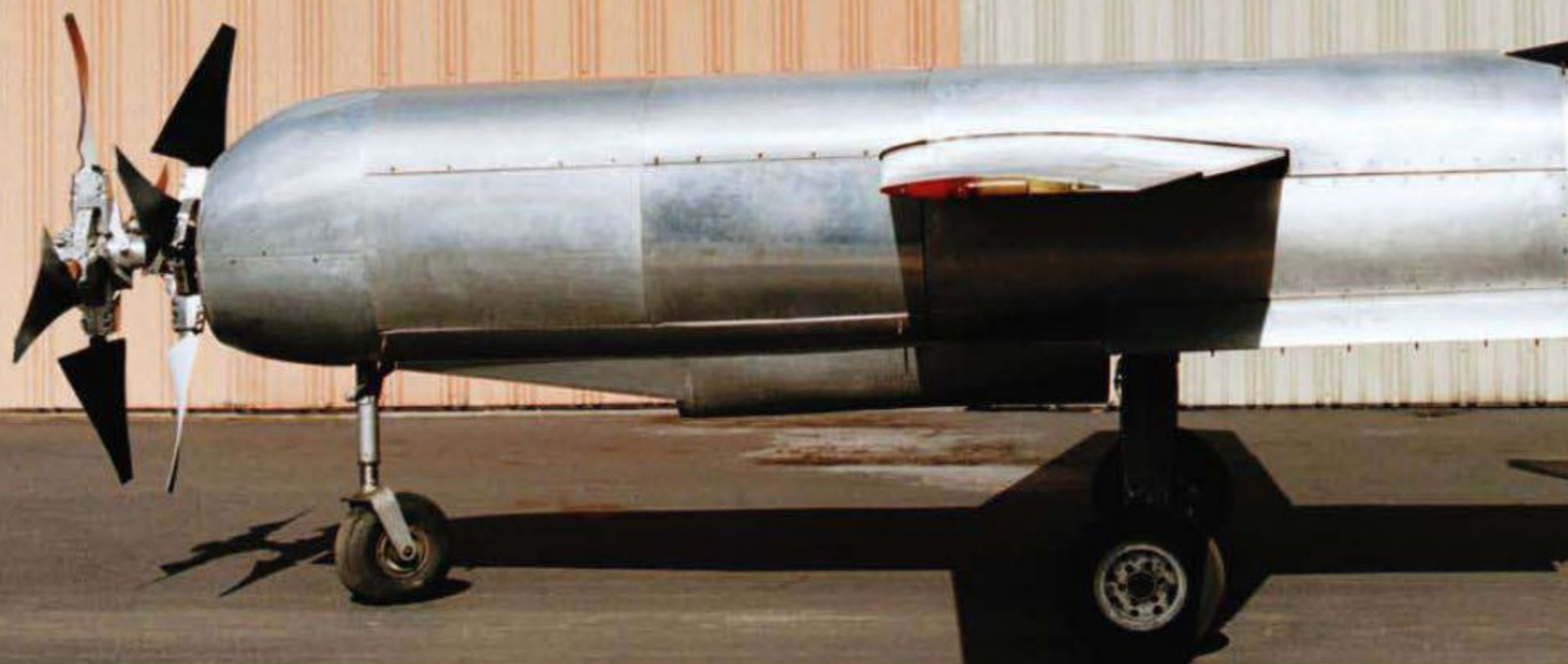
D I Y

Flight

It's good to be an amateur airplane designer in the United States. Engineering software is sold on the shelves, American airspace is the most permissive in the world, and hordes of fellow tinkerers are on hand to help build. There's no greater thrill than constructing your own plane—except flying it safely.

BY JEFF WISE

PHOTOGRAPH BY JAKE STANGEL



It was a warm, clear morning in West Texas, a fine day for flying as Mark Stull cruised low over rocky, cactus-filled rangeland. With a popping sound, the control stick suddenly jerked and the plane's nose tipped down. Stull instinctively hauled back on the stick and the nose came up, but he could tell something was terribly wrong by the plane's lack of responsiveness. He had to hold the stick almost all the way back just to maintain level flight. Even though he knew the craft's every wire and strut—he had built the airplane from scratch, after all—Stull didn't know what the problem could be. "I couldn't think of anything that would suddenly slack the 'up' elevator cable like that without letting go completely," he recalls.

Nerves on edge, Stull nursed the stricken craft 8 miles back to the



DAVID ROSE IS THE RAREST KIND OF AVIATION ENTHUSIAST—HE DESIGNS, CONSTRUCTS AND FLIES HIS OWN HIGH-SPEED AIRPLANES. HE'S BUILDING THIS CRAFT, THE RP-4, TO BEAT A 22-YEAR-OLD SPEED RECORD OF 528 MPH.

airfield, landed and jumped out to examine his airplane. A clamp holding the pulleys that fed a cable to the plane's tail had broken and was barely hanging on, like a fingernail on a cliff. "If I'd hit the slightest bit of turbulence, it would have popped off," Stull says. "I would have lost control, and I'd be dead."

That was the first time Stull escaped a potentially fatal accident in one of his homebuilt planes. But it wasn't the last. There was the time an engine mount failed in flight. And there was the time his muffler fell off and hit the spinning propeller. But as far as Stull is concerned, a few mishaps are all part of the game.

The 59-year-old former auto mechanic belongs to a tiny subculture that takes up the ultimate engineering challenge: designing an airplane, building it from parts and wagering lives on its airworthiness by flying the creation. "It's a borderline obsession for some people," says Jake Crause, administrator of homebuiltairplanes.com, the community's online nexus.

No other country has produced a more storied tradition of aeronautical innovation than the United States, and the vibrancy of the homebuilder community is an extreme testament to this legacy.

AVIATION AMBITION: BUILD IT YOURSELF

Want to take to the skies in a plane that you've designed and built yourself? You've got a long climb ahead of you, but some inexpensive tools and a supportive community of like-minded pilots will help you on your way.

This kind of creative aeronautics has never been safer or easier to pursue. Inexpensive computer-aided design (CAD) programs can configure airframes, and off-the-shelf flight simulations can verify the blueprints before a designer cuts metal. These programs have helped usher in safe, successful aircraft that can outperform professional models, win races and catch the attention of admirers at air shows.

Still, Stull prefers the intimacy of old-fashioned ways, using pencil and paper to sketch plans that please his eye. Even load calculations can be a matter of intuition. "I have a knack for visualizing loads on structural parts," Stull says. "I calculate when necessary. So you just build it robust. But not too robust."

Homebuilt-airplane makers are actually a subculture within a subculture. Of the 23,000 amateur-built aircraft in the U.S., all but a minority were built from professional designs or assembled from kits. Only a handful of builders finish and fly the planes they design—and with good reason. An airplane is a complex piece of engineering. A design that is 99.9 percent perfect could still harbor a fatal flaw. "All it takes is one little thing," says Martin Hollmann, an aeronautical engineer who conducts seminars on aircraft design. "All you need is the bolt to break on the elevator and you can kiss your ass goodbye."

According to the National Transportation Safety Board, homebuilt aircraft are three times as likely to wind up in a fatal accident as industrially manufactured light aircraft. The agency doesn't keep separate records for planes designed by hobbyists, but the accident rate for those is likely even worse. One of the ways that pilots get into trouble is by improvising tweaks or substitutions to established plans. John Denver, for instance, died in 1997 while flying a kit plane its builder had modified with a relocated fuel valve that Denver apparently had trouble reaching after one of his tanks ran dry. With amateur-designed homebuilts, the problem is even worse: The planes are improvised from tip to tail.

1. Build virtually first

To test how well your ideas will work in practice, buy a copy of X-Plane, a program that lets you design a plane and then fly it over realistic landscapes. Homebuilt designer David Rose uses the program in conjunction with the CAD program AirplanePDQ (combined cost: \$198). "With those two programs," he says, "I can do everything a \$30,000 design suite can do."

2. Design the structure

To configure actual parts and solicit advice on how to put them together, crack open Martin Hollmann's book *Modern Aircraft Design*. Hollmann also offers design classes at fly-ins, and structural consulting for intrepid airplane homebuilders (aircraftdesigns.com).

3. Get support

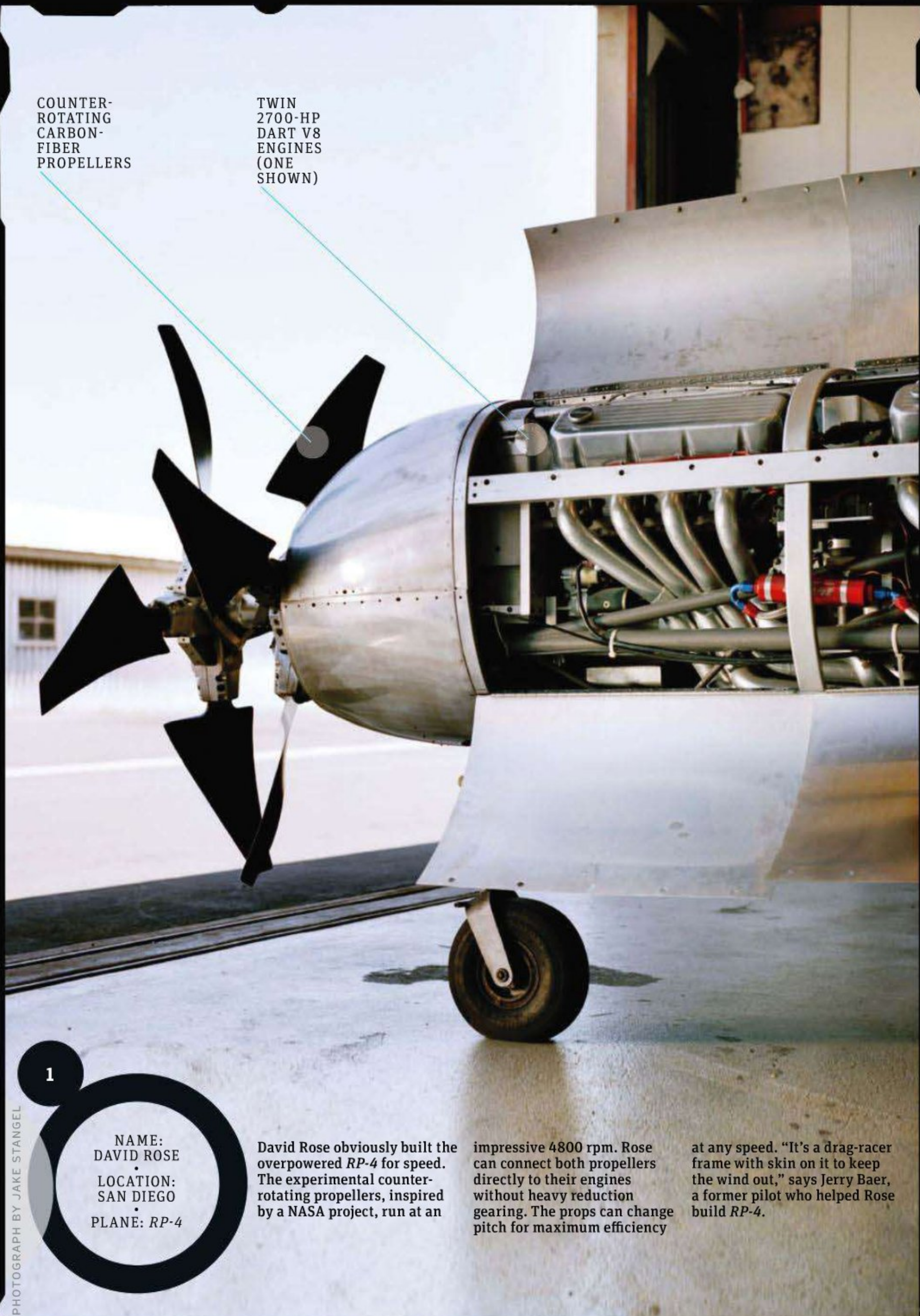
The Experimental Aircraft Association, an organization of aviation enthusiasts, has branches all over the world. Local members can offer encouragement, advise you on technical issues and even help do the work. "A lot of people are willing to volunteer their time just to be involved in a project," Rose says.

4. Get to work

People who build planes of their own design tend to be retired folks with a lot of energy. "It's going to take at least two years of full-time work, including weekends," Hollmann says. "And that's if you do everything right."

COUNTER-
ROTATING
CARBON-
FIBER
PROPELLERS

TWIN
2700-HP
DART V8
ENGINES
(ONE
SHOWN)



1

NAME:
DAVID ROSE
•
LOCATION:
SAN DIEGO
•
PLANE: *RP-4*

David Rose obviously built the overpowered *RP-4* for speed. The experimental counter-rotating propellers, inspired by a NASA project, run at an

impressive 4800 rpm. Rose can connect both propellers directly to their engines without heavy reduction gearing. The props can change pitch for maximum efficiency

at any speed. "It's a drag-racer frame with skin on it to keep the wind out," says Jerry Baer, a former pilot who helped Rose build *RP-4*.

PLANES TO ORDER:

SOME ASSEMBLY
REQUIRED

Not totally committed to building an airplane from scratch? Consider buying a kit plane instead. Many manufacturers produce partially assembled airframes. Some companies even allow you to come to their factory and assemble the kit with the help of employees, potentially cutting the build time from months to weeks.

1. Shop around

Before you jump in, make sure the plane you're going to build is the right one for you. Read up on the various available models. The more successful designs have active online forums where builders can share their expertise. "Don't just base your decision on what a plane looks like," says Andy Chiavetta, a crew chief for Reno air-races pilot Darryl Greenamyer. "Talk to people who've flown them."

2. Dabble

There are three main construction materials used in homebuilt planes: wood, metal and composite. Each has its own advantages and requires different aptitudes. Try them out to determine which suits you best. Every year the massive EAA AirVenture convention in Oshkosh, Wisc., holds hands-on workshops where would-be homebuilders can try different techniques.

3. Start small

Manufacturers such as Van's Aircraft sell partial kits. Buy the tail, and if building it is too hard or unsatisfying, you can rethink your options without wasting months of work and thousands of dollars.

4. Be realistic

Even if you're involved in a builder-assist program, constructing a functioning aircraft requires a serious time commitment. "There are an awful lot of kit planes out there that get started and are never finished," Chiavetta says.

And that challenge is the real joy of building a plane from scratch rather than assembling a kit plane from a vendor. "I started with a piece of paper, and now I have an airplane," says air-race team crew chief Andy Chiavetta, who recently flew his self-designed plane after eight years of construction. "That's extremely thrilling."

An amateur aircraft designer can tailor a plane to fit his or her precise requirements, no matter how outlandish. Take David Rose. Inside his hangar at Montgomery Field in San Diego, this former airline pilot is building a machine that he hopes will earn him aeronautical immortality. If all goes according to plan, a thunderously overpowered racing machine called *RP-4* will reach a straight and level speed in excess of 528.3 mph and become the world's fastest piston-driven plane. The 22-year-old record is held by a modified World War II-era Grumman F8F Bearcat.

Rose has been obsessed with speed all his life. In his teens, he built drag racers and started a weekly race meet in Petersburg, Va., near his hometown. Then he joined the Air Force, where, impatient to break the sound barrier (761 mph at sea level), he took an F-86 to 30,000 feet and then dove straight down on full afterburner. In civilian life, he flew (more responsibly) passenger jets for American Airlines.

In 1990, Rose found inspiration at the National Championship Air Races in Reno, Nev., where souped-up planes tear around a closed circuit 50 feet off the ground at speeds exceeding 500 mph. He bought a used Pitts Special biplane and won a trophy with it in 1992—and then decided he could do better. Using off-the-shelf engineering software, he designed his own biplane.

No big deal, Rose says: "You just crack the books and buy some computer programs." With the help of former airline pilot Jerry Baer and local mechanic Eric Hereth, Rose built the plane in his hangar in 10 months. Powered by a 230-hp engine, it clocked 225 mph around the Reno circuit in 2002 and won Rose the Biplane Gold category four times.

His *RP-4* project is another beast entirely. Inside the cowling sit two engines, both 2700-hp Dart V8 "Big M" aftermarket drag-racing blocks, 598 cubic inches each, one mounted in front of the other. The massive engines suck 110-octane racing fuel at 120 gallons per hour. The exhaust stack produces 300 pounds of thrust—enough, Rose says, that "we could fly the plane on the exhaust alone."

Instead of linking directly to a single prop, the driveshafts turn a gearbox connected to a pair of counter-rotating propellers, 24-inch-long carbon-fiber blades. The experimental design, which offers greater efficiency than conventional props, was developed by NASA engineers for the rigors of high-Mach flight. At full throttle, the pro-



In 1989, Cory Bird was a shop fabricator at Scaled Composites, famed aviation designer Burt Rutan's company, when he decided to use his knowledge of composite construction to

build aeronautical art. "I wanted to show what I could do," he says. Over the next 14 years he conceived and created a two-seat airplane he called *Symmetry*. The sleek aircraft can reach 284 mph at 3000 rpm. The labor of love proved so exquisite that it won a Grand Champion prize at the Experimental Aircraft Association's big air show in

Oshkosh, Wisc. Today, the 53-year-old Bird, now a project manager at Scaled, is hard at work on another design for a plane that will carry two and land on shorter airstrips than *Symmetry*.

NAME:
CORY BIRD
LOCATION:
MOJAVE, CALIF.
PLANE:
SYMMETRY

2

LANDING
GEAR:
ONLY
THE TAIL
WHEEL
RETRACTS.

ENGINE:
200-HP
LYCOMING

ENGINE:
25-HP
KAWASAKI
WITH A
3-TO-1 BELT
REDUCTION
DRIVE

CLIMB RATE:
400 FEET PER
MINUTE

4

NAME: CHRIS
CHRISTIANSEN
LOCATION:
TEMPE, ARIZ.
PLANE: SAVOR

Self-taught 31-year-old amateur builder Chris Christiansen designed and flew his third homebuilt airplane, the high-wing *Savor*, in just 15 months. That's especially impressive considering that Christiansen designs with pencil and paper. Yet the *Savor*, which is intended as a cross-country flying machine, looks very much like a professionally built airplane—a good deal, in fact, like Cessna's new entry in the light-sport aircraft market, the *Skycatcher*. Except that *Savor* can go nearly 200 mph, 65 mph faster than Cessna's plane.

3

NAME:
MARK STULL
LOCATION:
CRISTOVAL, TEXAS
PLANE:
LUCKY STARS

Homebuilt airplane pilots are motivated by more than aerodynamics. Mark Stull built *Lucky Stars* with a 4.5-foot-diameter ring tail. It took some

clever engineering—and some hair-raising test flights—to make it work. Stull added a hydraulic damper to ensure that the tail didn't swing too far to the side, and balanced the tail by adding weights to the ring. He then moved the seat forward to maintain the craft's center of gravity.

pellor's tips break the speed of sound.

Rose and Hereth are obsessed with their high-speed project and expect other people to feel the same; the odder the construction, the more the builders want to show it off.

Outside the open hangar doors, a sunset is turning the underbelly of the quilted cumulus Barbie-pink, and the breeze carries the sweet tang of eucalyptus. Rose runs an appreciative hand along the boxy skeleton of 4130 moly-chrome tubing—another of the craft's unusual features.

Most modern planes have monocoque construction, with the metal or composite skin providing much of the structural strength. *RP-4* is built more like a skyscraper, with an internal truss bearing all the major stresses.

"This structure is designed to survive an impact of 300 mph," Rose says.

"If the angle is less than 10 degrees," Hereth adds.

Mark Stull sits on a folding chair under the wing of his ring-tailed yellow ultralight, *Lucky Stars*. Similarly fanciful flying machines are lined up in rows on either side of him, and behind his back a plastic mesh fence marks the edge of a grass runway upon which a dazzlingly eclectic procession of aircraft have been taking off: powered parachutes, flying boats and even a miniature P-51 Mustang.

Wiry and compact, with close-cropped hair, Stull has an angular face that seems as if it were designed for minimum wind resistance in an open-frame flying machine. He has traveled halfway across the country to attend one of the premier events on the homebuilder's calendar, a Lakeland, Fla., fly-in called Sun 'n Fun. One week every spring, aerobatic flight teams, owners of antique military aircraft and all manner of merchandise dealers converge amid throngs of aviation enthusiasts.

There are not many people who build their own planes, but they command outsize respect in the aviation community. They may not all have technical backgrounds, but they like to work with their hands and are confident of their skills. Above all, they are maniacally determined and persistent. "I don't think they could keep themselves from doing it even if they tried," HomeBuiltAirplanes' Crause says.

Their unique levels of self-motivation mean that builders like Rose and Stull tend to be solitary, beaver away on their creations



alone or with a small number of friends. But when they need help, there's a large, very supportive network of builders spread across the country. "It's a team effort," Hollmann says. "We try to stick together and help each other."

An event like Sun 'n Fun is one of the few occasions when the tribe gets to connect face to face, and the sense of communion can be electrifying: For once, these men are surrounded by human beings who not only understand what they're talking about, but actually care. A reporter from a kit-building magazine stops by and sits next to Stull. "What was the first flight like?" he asks.

"I almost crashed four times," Stull replies. He explains that he had built the control stick so that it hinged at the top instead of the bottom. "It was indescribable how confusing it was," he says. "I did a hop and almost crashed, and I tried again."

In the end, Stull wound up rebuilding the control system along more conventional lines. He is forever tinkering, reconfiguring and trying new ideas. "I can build a plane in three months," he says, "but it takes me up to a month to adjust it."

The importance of strong construction skills became apparent at Sun 'n Fun: The day before, a tornado trashed half the planes in this section of the airfield. Some were crumpled into balls of fabric and mangled spars. *Lucky Stars* made it through almost intact—the main boom holding its tail in place snapped, grounding it.

Later that afternoon, Stull wanders over to chat with ultralight

pioneer and fellow homebuilder John Moody, who is reclining on a lawn chair next to a biplane without a tail or fuselage.

Stull wonders aloud if the ultralight innovator might be asleep, but Moody jumps up, and he and Stull fall into a conversation about the pros and cons of *Lucky Stars*' ring-shaped tail. "It's cool," Moody says. "I don't know of any advantages, aerodynamically."

"It's mainly for fun," Stull says. He points out that it has the same aerodynamics no matter how the plane is oriented on its longitudinal axis. That leads him to ruminate about his next possible project. "I've got some wild ideas," Stull says. "Since the ring tail worked, why not ring wings? You could fly the plane on edge, sideways!"

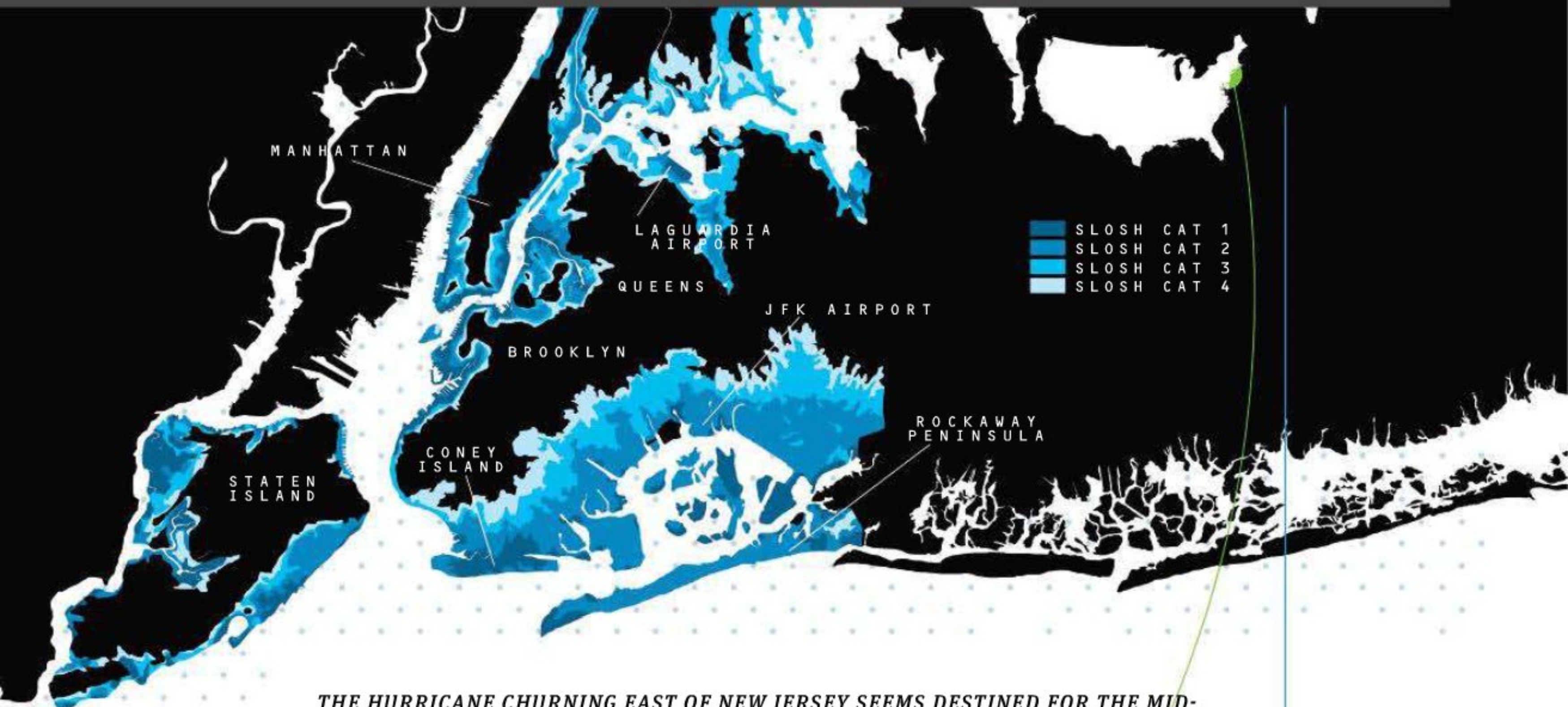
Stull laughs, slapping his knee. His outlandish ideas have a history of actually taking flight. In fact, he says, he's already begun penciling sketches. **PM**

BY DOUGLAS FOX

SUPER STORMS



A SPATE OF SEVERE WEATHER EVENTS HAS LEFT LARGE SWATHS OF THE U.S. DEVASTATED. TIME TO FACE THE NEW HIGH-HAZARD REALITY—AND GET PREPARED.



THE HURRICANE CHURNING EAST OF NEW JERSEY SEEMS DESTINED FOR THE MID-ATLANTIC. THEN A COLD FRONT DESCENDING OUT OF CANADA NUDGES THE CATEGORY 2 STORM NORTHWEST INSTEAD—SETTING IT ON A WORST-CASE COURSE FOR NEW YORK CITY. ¶ New York Harbor has often sheltered the city, dissipating energy from violent gales that start at sea. But now it plays an opposite role: It turns an otherwise moderate hurricane into a disaster. As the eye of the storm passes over Staten Island, the 100-mph counterclockwise winds shove 500 million tons of seawater directly into the harbor. The narrowing shorelines and shallowing sea bottom cause the mass of water to build. By the time the storm surge washes over the shores of Brooklyn, Queens and Manhattan, it towers 11 to 15 feet high.

Water flows through New York's financial district and reaches 2 miles into southern Brooklyn and Queens, flooding 2900 miles of roads. Impromptu rivers gush into subway stations and pour through hundreds of sidewalk gratings.

In Manhattan, the lower levels of Penn Station and Grand Central fill with water. The subway floods within 40 minutes—paralyzing the city's chief form of public transportation. Three of the four automobile tunnels linking Manhattan to the outer boroughs and New Jersey also flood, submerging hundreds of cars stranded in traffic jams during evacuation. A million people lose electricity and phone service as floods shut down 10 power plants and the emergency generators powering cellphone towers.

While this scenario may sound like yet another apocalypse-in-New York summer blockbuster, it was produced using calculations from the U.S. Army Corps of Engineers—

and it's been given serious attention from government planners. That 1995 Army Corps report and a 2006 analysis by the Department of Homeland Security predict that a Category 4 hurricane scoring a direct hit on New York City would inflict \$500 billion worth of damage—quadruple that wrought by Category 5

New York City

According to the Metro New York Hurricane Transportation Study, an analysis by the U.S. Army Corps of Engineers, a Category 4 hurricane could inflict \$500 billion worth of damage. SLOSH computer models from the city's Office of Emergency Management show that a direct hit by even a Category 2 storm would completely inundate Rockaway Peninsula; a Category 3 storm would put JFK airport under 19 feet of water.



SEVERE STORM WARNING

Hurricane Katrina in 2005.

A third study, released this September by New York state, predicts that an even milder, Category 1 hurricane or winter nor'easter could inundate the city's subway and cause \$58 billion in losses. Experts don't consider such disastrous flooding a mere possibility; they believe it's a certainty—a one-in-100-year event. Sea level rise will upgrade it to a one-in-35-year event by 2080.

"We've been very, very lucky because we haven't had that [direct hit]," says Cynthia Rosenzweig, a climate-impact scientist at the NASA Goddard Institute for Space Studies in New York who has helped guide the city's storm- and climate-planning effort. "But the potential vulnerability for that is very high."

Every region of the U.S. is subject to catastrophic storms of one type or another. While the severe floods and tornadoes that devastated large swaths of the country this spring surprised many people, there's no reason they should have. Annual losses from natural hazards have increased severalfold over time—costing the nation \$573 billion in crops and property since 1960. Americans are turning even routine storms into full-blown disasters by settling where they strike. Then, when vulnerable infrastructure is swept away, people have exhibited a steadfast commitment to rebuilding it.

"There are more people living in what we might consider to be high-hazard areas," says Susan Cutter, a disaster scientist at the University of South Carolina in Columbia. These include coastal areas, floodplains and places especially prone to tornadoes and landslides. By 2040, 70 percent of the U.S. population—which should then number 400 million—is expected to concentrate in 11 megaregions, seven of which

occupy coastal counties.

If New York—part of the Northeast megaregion—suffers a direct hit, workers will spend weeks pumping a billion gallons of brackish water out of its subway and train tunnels. The salt will corrode power lines, transformers and thousands of brakes and switches that control the trains. Some subsystems could take a year or more to restore.

To avoid such a scenario, New York state recommends the city invest well over \$100 million a year in storm protections. City planners are already experimenting with dozens of low-tech fixes, says Adam Freed, deputy director of the Mayor's Office of Long-Term Planning and Sustainability. These include raising subway vents above sidewalks, installing several-inch-high barriers around subway entrances and using porous pavement. They've also considered building lips around rooftops to slow the percolation of water into streets and sewers, because every inch of rain that falls on New York translates to a billion gallons of storm water that

must be managed.

Some observers, such as Malcolm Bowman, an oceanographer at the State University of New York at Stony Brook, have even suggested that four massive barriers be built across the waterways surrounding the city. The arms would swing shut during severe storms—much like those of the Maeslantkering, a barrier that protects the Port of Rotterdam from surges in the North Sea.

CANTON, MO., A TOWN OF 2500 on the upper Mississippi River, has been at the center of an increasingly high-stakes environmental wager for years now. In the summer of 1993, a high-pressure system stalled over the southeastern U.S., forcing the jet stream, laden with moist air from the Gulf of Mexico, to the north, where it collided with cold air from

CATEGORY 3 HURRICANE



In 2010, the Insurance Institute for Business & Home Safety Research Center tested two different home-construction methods against hurricane-force winds.

1 | Heat Engine

Hurricanes are massive dynamos powered by the evaporation of water and its subsequent recondensation into clouds and rain. Each gallon of water that evaporates and condenses carries about as much thermal energy into the atmosphere as that contained in 1 cup of gasoline.

2 | Hotspot

Hurricanes spawn over patches of ocean where the surface water has warmed to at least 80 F down to a depth of at least 160 feet. Ocean water evaporates in these hotspots and the moist air rises.

3 | *Updraft*

The rising of warm, moist air creates a low-pressure zone, pulling in more air from nearby areas, which also moistens and rises. The continued updraft is fed by condensation of evaporated water into clouds and rain. The condensation dumps energy back into the air, warming it and making it more buoyant.

4 | Spiral

Surrounding air flows into the low-pressure zone in a spiral pattern. This inward-spiraling air forms the hurricane's destructive winds. The direction of the spiral is determined by the Coriolis effect—a byproduct of the Earth's rotation.

5 | *Sinking*

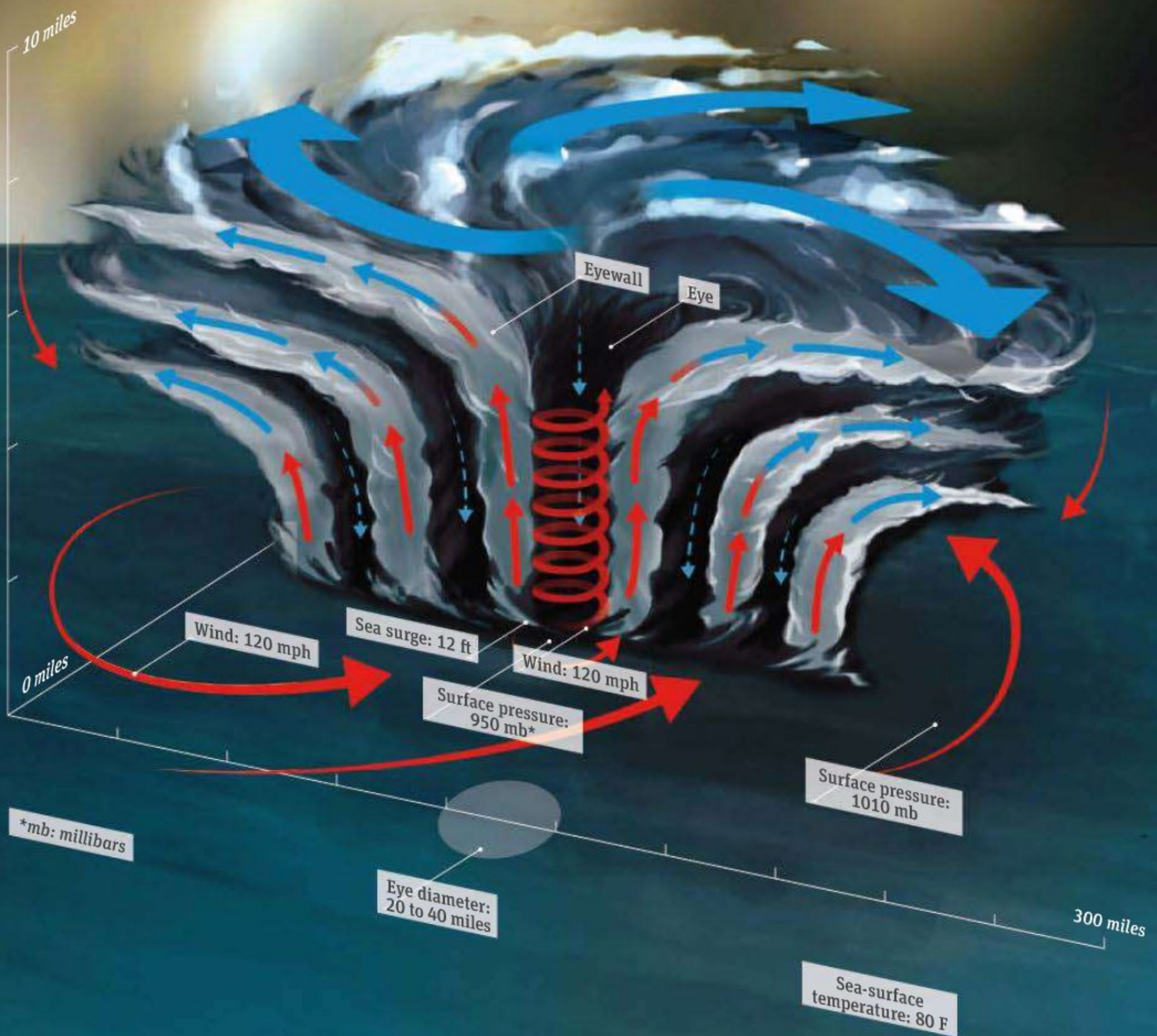
Air is ejected from the top of the storm at an altitude of about 40,000 feet. This cooled, dried air sinks through the eye of the storm or else flows out and sinks in the outer bands of the storm, forming areas without rain.

6 | Magnitude

At its peak, a hurricane can dump 5 cubic miles of rain per day and unleash thermal power (freed by condensation of that water) at a rate of 6×10^{14} watts—equal to 200 times the amount of electricity generated by humans worldwide. Only about 0.25 percent of this power is converted to wind.

7 | Effects

In addition to destructive winds, hurricanes can pile up sea surges higher than 20 feet (which are responsible for most deaths). Even after winds dissipate inland, rain can cause flooding for days—as happened with Hurricane Mitch, whose floods and mudslides killed nearly 20,000 people in Central America in 1998.

ILLUSTRATIONS BY **KIJI MCCAFFERTY**

FLOOD



Canada. As a result, rainstorms drenched the upper Midwest. Many towns received two to six times the normal amount of rainfall for June and July.

The Mississippi River crested at 13.8 feet above official flood levels in Canton, overtopping several local levees. That year, more than 1000 levees ruptured or overflowed along the Mississippi and Missouri rivers. Seventy towns, including Canton, flooded. The water stayed high for six months.

According to government statistics, the flood that Canton experienced in 1993 was a freak, one-in-500-year event—not something that would happen again soon. That estimate came from analyzing the 140-year historical record—calculating the frequency of floods of various magnitudes and extrapolating the curve out to events at a scale never seen before. If only it were that simple. Canton suffered another 500-year flood in 2008, a 70-year flood in 2001, and 10-year floods in 1996, 1998 and again in early 2011. Plenty of towns across the region have suffered similar events.

“We’re witnessing higher and higher floods over time,” says Robert Criss, a hydrogeologist at Washington University in St. Louis. “We are seeing higher and far more frequent floods than government estimators say we should.”

The data are too noisy to chalk that trend up to increased rainfall. Instead, official statistics may underestimate the severity of floods in this region because records are too short to reveal the full variability of the climate. “We have no idea what Mother Nature is capable of dishing out,” Criss says.

PEOPLE TEND TO VIEW earthquakes and hurricanes as the most damaging natural disasters—but a steady rain could do far worse. In the winter of 1861 to 1862, California experienced a

PREVENT FUTURE DAMAGE

Improved statistics Flood-risk statistics for the upper Mississippi River seriously understate the potential for flooding. In St. Louis and dozens of smaller cities and towns, a one-in-200-year flood may actually occur every 50 years. Correcting those risk numbers could raise flood insurance rates, curb development in high-risk areas, and ultimately reduce federal flood insurance payouts.

Coastal buffers During the 2004 Indian Ocean tsunami, mangrove trees as little as 300 feet deep blunted tsunami flow pressure by up to 90 percent. Development has substantially reduced mangroves that naturally occur along the U.S. Gulf Coast from Texas to Florida; restoring them could help protect coastlines against hurricane storm surges.

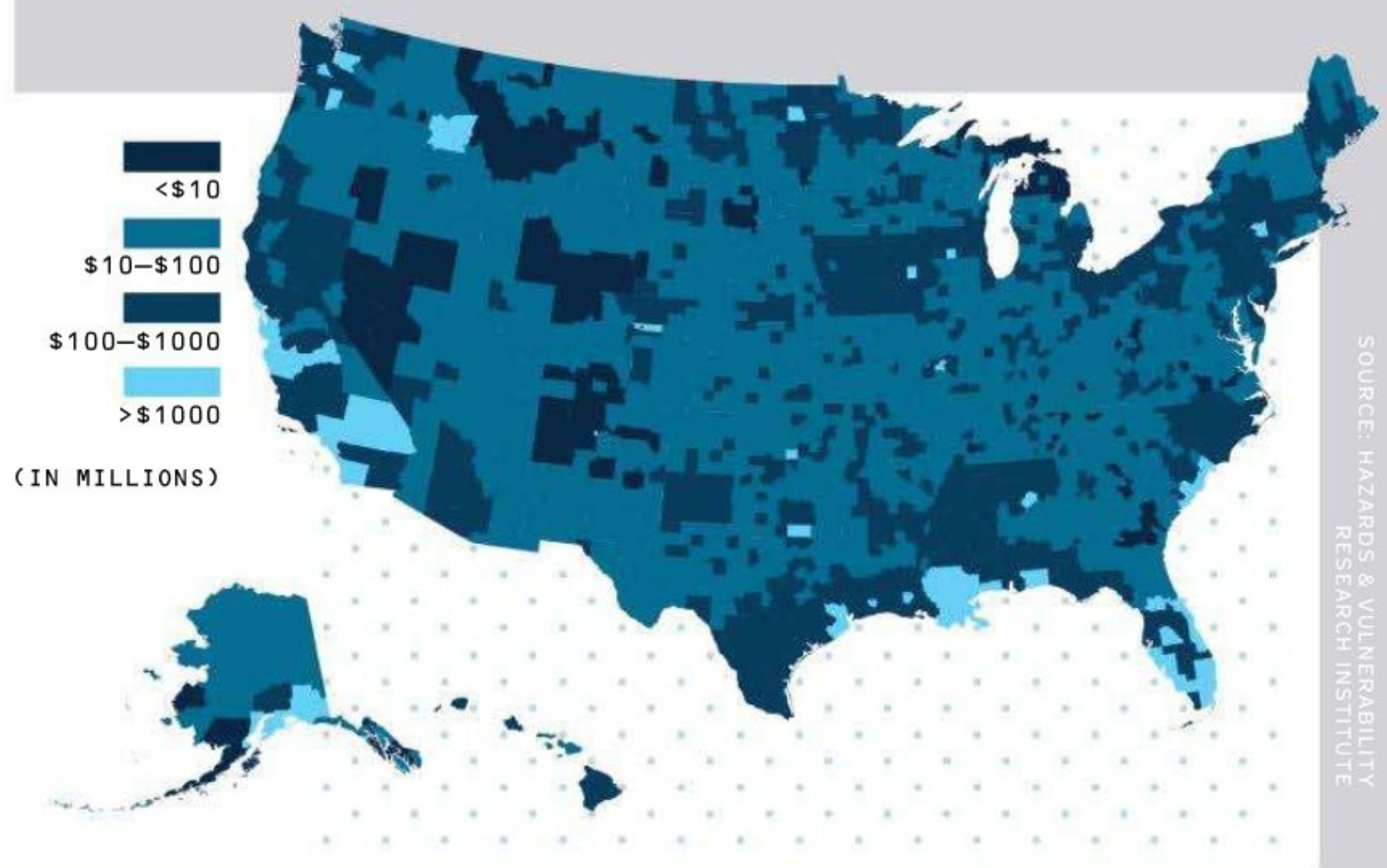
Proactive mapping Coastal cities need to retool zoning laws to incorporate the 2 to 4 feet of sea-level rise expected by 2100. Jonathan Overpeck at the University of Arizona has produced elevation maps of 180 coastal U.S. cities—on average, almost 10 percent of their area will be inundated by 1 meter (3.28 feet) of sea-level rise—with larger areas at risk of floods or extreme tides.

Handheld warnings Quicker flood warnings could help people react in time. The U.S. Geological Survey is currently developing smartphone apps that track users’ locations and warn them if a flash flood is headed their way. The apps could become available within five years in Sacramento, Los Angeles, San Diego and other flash-flood-prone areas.

Floating structures In areas where floods are a problem but wind, waves and strong currents are not, one solution is to build infrastructure that floats. In New York City, for example, several oil-fired power plants on floating barges provide electricity during peak demand. These “power barges” can move upriver during storms and then restore power after the surge has passed.

THE COST OF IN ACTION

There were 1764 presidential disaster declarations due to natural hazards—such as severe weather and wildfire—between 1960 and 2009, costing the U.S. \$147 billion.



SOURCE: HAZARDS & VULNERABILITY
RESEARCH INSTITUTE

The Maeslantkering storm-surge barrier, in the Netherlands' New Waterway, automatically swings shut to protect the Port of Rotterdam against severe flooding from the North Sea. Similar barriers have been proposed for the waterways around New York City.



series of rainstorms lasting 45 days. The Central Valley became a shallow lake that lingered for months. Newspapers described people traveling the streets of Sacramento in boats.

A team of 40 scientists recently modeled the effects of such a roughly 500-year storm if it were to strike California today. "There's no way that the magnitude of the storm and the subsequent flooding could be contained by the existing flood structures," says Justin Ferris, a hydrologist at the U.S. Geological Survey's California Water Science Center in Sacramento. "Such a flood would be devastating."

Ferris and others estimate that a 300- by 20-mile swath of the Central Valley would flood. Waterlogged soil would trigger hundreds of landslides. While the

USGS considers a magnitude 7.8 earthquake along the San Andreas fault an equally likely event, the California storm would cost nearly three times as much—\$300 billion in direct damages.

Plenty could be done to soften the impact of massive downpours, but it will mean undoing 150 years of misguided policy. Engineers have progressively walled in the upper Mississippi and lower Missouri rivers as they straightened them for ship navigation—in some places decreasing the rivers' width by two-thirds since 1875. This reduced their ability to expand during floods. Compared with a century ago, an equivalent amount of water flowing down the upper Mississippi River now causes the water to rise 10 to 12 feet higher.

In Chesterfield Valley, Mo.,

mall and homes worth several billion dollars have been constructed in the past decade on land that was underwater in 1993—requiring the government to build up levees. Breaking that cycle, Criss says, will mean putting an end to misleading flood-risk statistics and the artificially cheap federal flood insurance that goes hand in hand with them. "It enables people to obtain financing for very economically damaging projects," he says. "It puts the taxpayer on the short end of the stick."

You might say the Army Corps of Engineers took a small step in the right direction on May 3, 2011. That's when it dynamited a 2-mile section of levee on the Mississippi River to divert water onto farmland and save the town of Cairo, Ill., from flooding. But the ensuing wall of water inflicted long-term damage—scouring away topsoil, gouging gullies 8 feet deep and dumping sand.

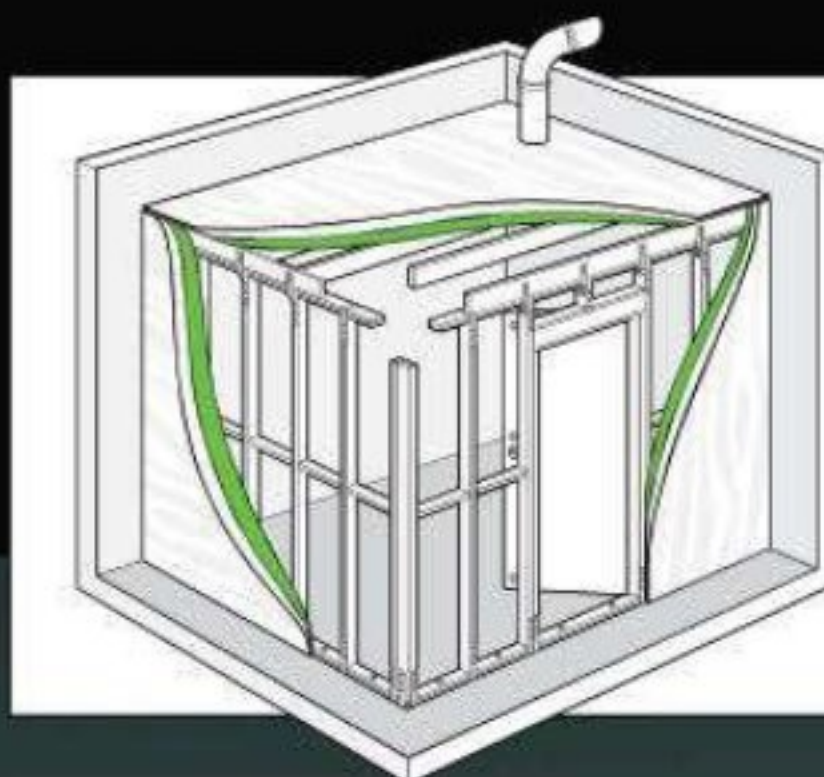
A better approach is to plan for flooding by building lower levees that are designed to overflow, allowing the farmland to flood more often—and more gently. "We need a system that uses farmland for floodwater storage," Criss says. "It will help the environment, and the farmers can be compensated for that, just like we compensate them for letting land lie fallow." Such a system would pay for itself by reducing rebuilding costs; flood damages currently total \$1 billion to \$10 billion per year in the U.S.

FLOOD AND HURRICANE RISK can at least be predicted: It is heavily influenced by topography, and the storms and floodwaters can be tracked for days in advance. But severe tornadoes, like the ones that tore across the central and eastern U.S. in 2011, pose a very different challenge.

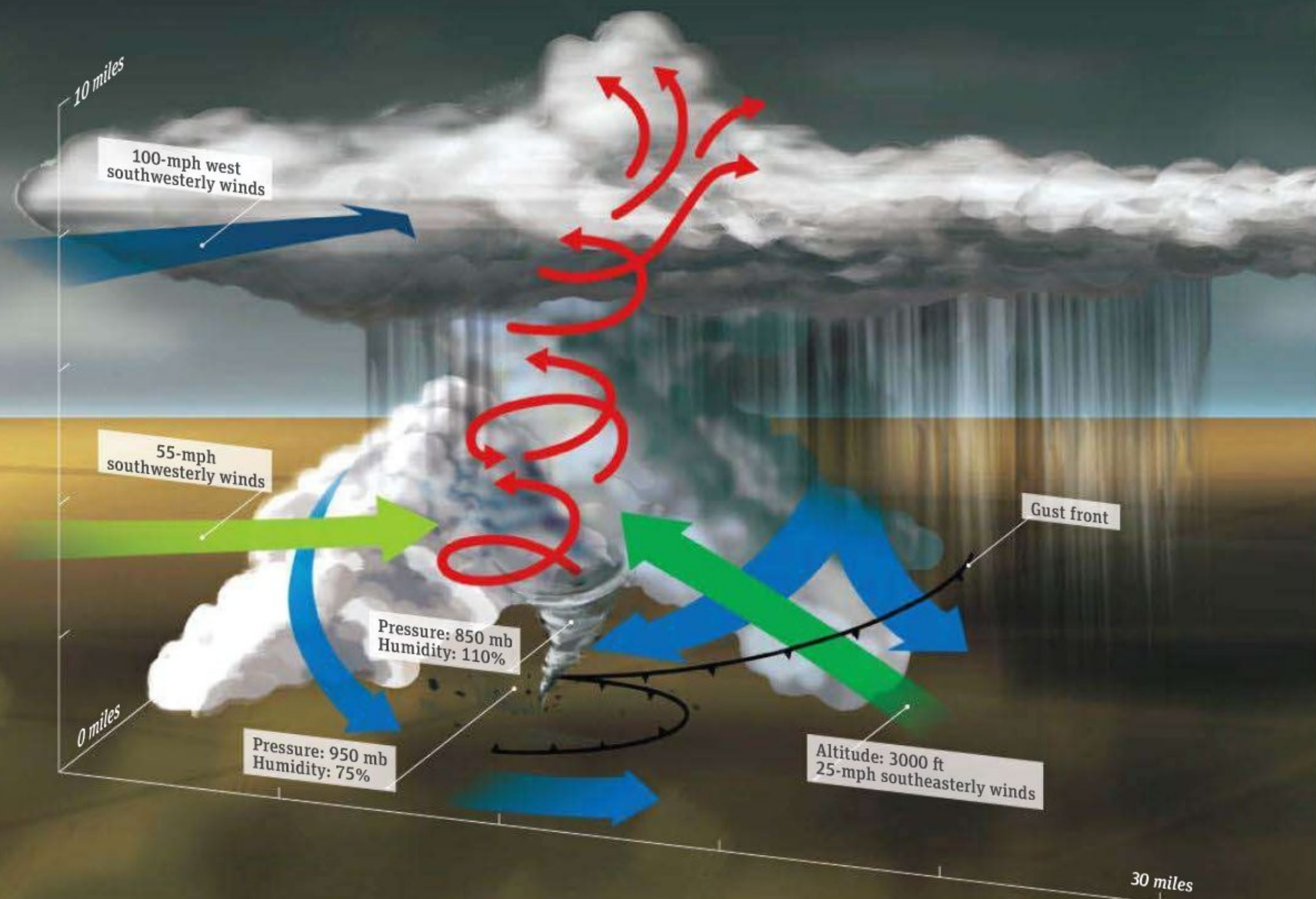
The tornado that ripped through Joplin, Mo., on May 22, a 5 on the enhanced Fujita (EF) scale, existed for just 38 minutes.



EF4 TORNADO



Researchers at Texas Tech have developed plans for DIY storm shelters made by pouring concrete into foam forms. The walls are two layers of plywood and one layer of 14-gauge steel. The doors close with triple deadbolts, and ducts equalize the pressure inside and out.



1 | Supercell

Tornado-spawning thunderstorms, called supercells, arise where a current of low, warm, moist air traveling north from the Gulf of Mexico flows underneath a higher, cooler mass of air traveling east. Shear from these opposing winds causes the entire supercell to rotate slowly.

2 | Updraft

The low, moist air is warmed by sunlight, making it increasingly buoyant. The moist air breaks through the cooler air above and rises. As it does so, vapor condenses into water droplets—dumping the heat of condensation back into the rising air, warming it and further feeding the updraft that will ultimately power the tornado.

3 | Downdraft

The updraft is counterbalanced by a downdraft of sinking air, which is cooled by rain. This cool, sinking air next to warm, rising air produces a pressure gradient in the bottom 3000 feet of the atmosphere, lending a spiraling motion to the updraft—which will become the tornado.

4 | Stretching

The supercell travels northeast, towing the updraft like a leash. Stretching causes the updraft to narrow. As this occurs, its spiraling winds accelerate—much like a spinning ice skater speeding up as she pulls in her arms and legs. A violent tornado is born.

5 | Pressure

The tornado's updraft creates a low-pressure zone at its core. That pressure differential relative to the surrounding air is roughly equal to that of a Category 5 hurricane—except that in the case of the tornado, the differential exists within half a mile rather than 100 miles—helping fuel ferocious winds that can far exceed those of a hurricane.

6 | Effects

Supercells don't just spawn tornadoes. They can also produce powerful downdrafting wind bursts miles from the tornado. These bursts can sometimes flip mobile homes. Supercells can also produce dangerous lightning and hail as large as golf balls or grapefruit.

By firing the “large debris cannon” in its research center, insurer FM Global can measure the impact of objects, like tree limbs or signposts, propelled by winds up to 130 mph.



During that time it plowed a path three-quarters of a mile wide through town, destroying nearly 7000 homes and tossing trucks 200 yards. Many people, such as Pizza Hut manager Christopher Lucas, reacted just in time: He crowded 19 people into his walk-in freezer. They survived, although Lucas—sucked out of the freezer as he held the door shut with a bungee cord—was among the 150 who died.

The tornado seemingly could have struck anywhere. The moist air that flowed from the Gulf of Mexico that day created a whole herd of potentially tornado-spawning thunderstorms, from Oklahoma to Minnesota. The Joplin tornado affected just a few square miles of that vast area—yet it did so with overwhelming fury. Its winds, over 200 mph, hammered buildings with four times the pressure that a Category 2 hurricane with 100-mph winds would have exerted.

It's possible to build a house to withstand 100-mph winds, providing partial protection against some weaker tornadoes. But 200-mph winds? “It's just not practical to design the entire building to withstand those kinds of pressures,” says Ernst Kiesling, an engineer at Texas Tech

University's Wind Science and Engineering Research Center. “It would be too expensive.”

Even if houses can't be protected from EF5 tornadoes, Kiesling has spent decades looking for ways to save the lives of the people inside them.

After a tornado killed 26 people and destroyed hundreds of homes in Lubbock, Texas, in 1970, Kiesling and his colleagues noticed a curious thing: Even in buildings that were blown apart, an interior bathroom or closet was sometimes left intact. It gave Kiesling an idea: Convert a small, windowless room in the house into a tornado shelter that could survive 250-mph winds.

Many of the fatalities in tornadoes occur when people are struck by projectile debris—the Joplin tornado, for example, drove all four legs of a chair through the walls of one house. So Kiesling's team tested their shelters with a gun that fired 2 x 4s at 100 mph (the speed at which they would be propelled by 250-mph winds). They settled on steel-reinforced plywood to make the structures puncture-proof. Such shelters can now be installed for \$3000 to \$10,000.

Researchers are working on other technical solutions to



tornado protection—for example, radar that provides earlier warnings. But societal trends continually work against even the best of efforts. “For any intensity of tornado, you're more likely to be killed if you're in a mobile home than in a permanent home—15 to 20 times more likely,” says Harold Brooks of the National Severe Storms Laboratory in Norman, Okla. Unfortunately, the proportion of Americans living in mobile homes has tripled since 1970 (and it is highest—about 15 percent—in the tornado-prone Southeast).

In this sense, the problems posed by tornadoes do bear a resemblance to those of hurricanes, floods and other severe storms. Some steps needed to minimize losses, such as stricter building codes and sturdier infrastructure, are well-known. They require greater investment. Other solutions, just as important, involve choosing what not to protect. Instead of applying brute force, they'll mean removing the perverse incentives that encourage people to build in high-risk areas. Because for those who find themselves in harm's way, even modest storms can be super. **PM**



**SEVERE
STORM
WARNING**

RETHINKING THE HOME OF THE FUTURE ☒

22 BIG IDEAS FROM THE 2011 SOLAR DECATHLON

BY HARRY SAWYERS © ILLUSTRATIONS BY ANDREA MANZATI
PHOTOGRAPH BY MISHA GRAVENOR



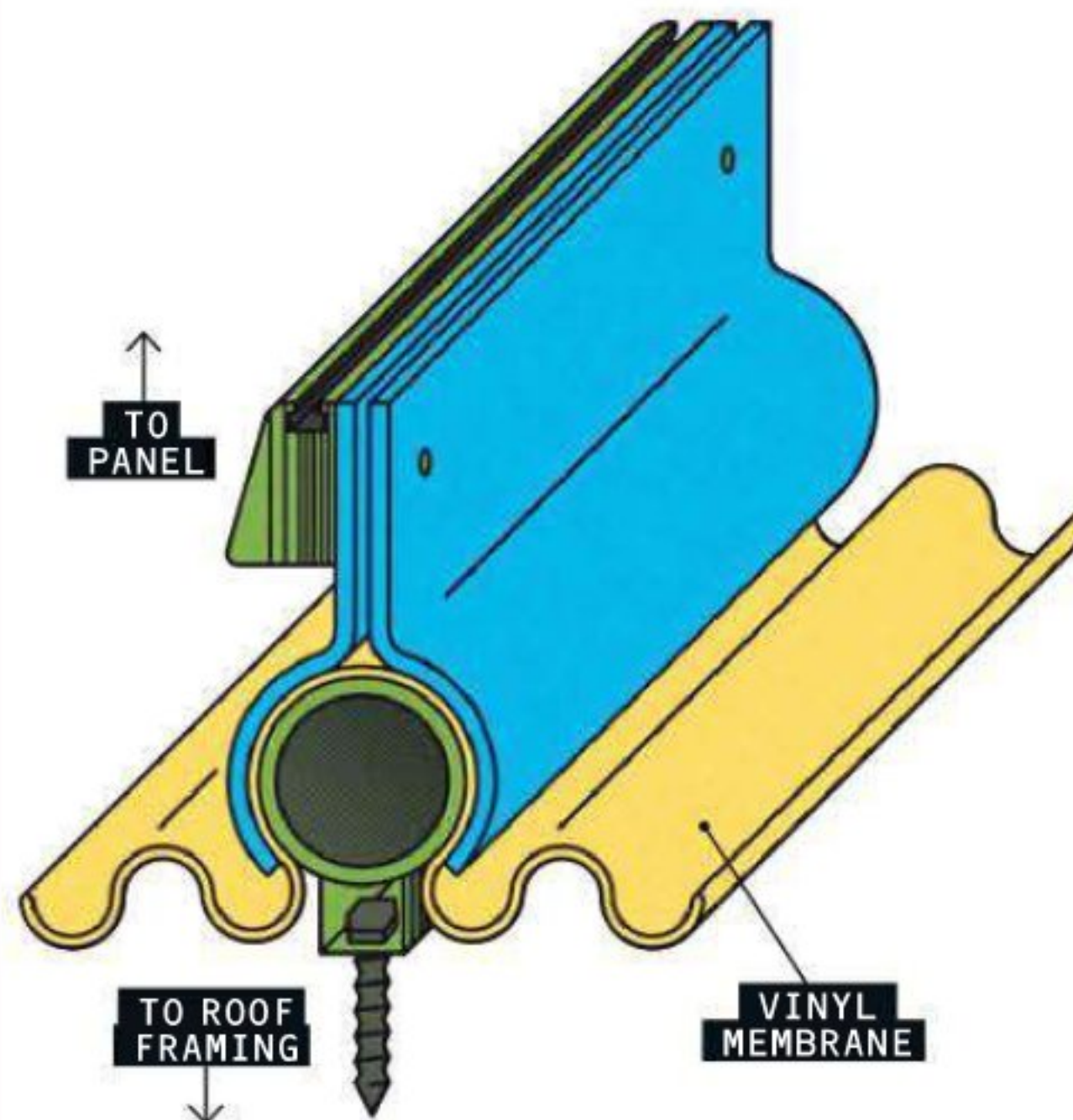
The appeal of the Solar Decathlon? "These are homes you can actually walk through, with systems you can see," Team California project manager Elisabeth Neigert says, standing in the partially built CHIP house on the Southern California Institute of Architecture (SCI-Arc) campus. "We come together from all over the world to tackle the problems of tomorrow's housing—to show what's possible today."

☒ The Solar Decathlon, a biennial contest in which 20 teams of college students build houses that produce as much energy as they consume, was in the ironic position of homelessness in January 2011: The competition had lost its spot on the National Mall in Washington, D.C. The news broke during the International Builders' Show, where teams had met to show off models of their projects. The students were bummed. So they got organized and lobbied Congress, and Team California's Elisabeth Neigert (left) pleaded their case in *The Huffington Post*. In the end, the students won. The competition, organized by the Department of Energy, will be held on the Mall Sept. 23 to Oct. 2. During that time, the public can tour the homes and see students testing brilliant ideas—like these 22—in real-world conditions, one watt at a time.

1-5

TEAM CALIFORNIA → CHIP

☒ CalTech and SCI-Arc's CHIP (Compact House, Infinite Possibilities) combines engineering and architecture to challenge conventional building practices with concepts like these:



SOLAR PANEL CLAMPS Rather than penetrating a rooftop with a racking system (which can void roofing warranties and lead to leaks), students combined panel-mounting IronRidge rails with a homemade clamp-and-pipe system that can pinch the panels into place while the vinyl roof membrane remains unbroken.

POWER FOR EV PARKING Planning for a vehicle isn't a competition requirement. But Team California figured out how to use CHIP's cantilevered upper floor to create an electric-vehicle carport under the bedroom. Beefy 10-gauge wiring connects an exterior outlet to a 20-amp breaker, using the 8.0-kw photovoltaic (PV) system to charge an EV.

AUTOMATIC A/C When asked to name the single best piece of CHIP's HVAC equipment, CalTech student Fei Yang rattled off a model number: Mitsubishi MXZ-2B20NA-1. This air conditioner takes infrared measurements of the house,

then automated louvers blow cool air to hot areas.

CONTROLS VIA KINECT A CalTech modification makes Microsoft's Kinect system for the Xbox 360 function like a next-gen Clapper. The system, described by designer Cole Hershkowitz as a "gesture- and location-based home-control interface," senses specific body motions to turn on lights, fire up the stereo or switch on the TV.

BILLBOARD SIDING The team used vinyl-coated polyester, which could be recycled from billboards, as impervious siding. The white cladding also wraps the roof.

6-8

TEAM NEW JERSEY → ENJOY HOUSE



THERMAL MASS ▶ Team New Jersey (Rutgers and the New Jersey Institute of Technology) squeezed 6 inches of expanded polystyrene insulation inside its home's foot-thick precast concrete walls, floor and roof. In winter, the slabs absorb daytime solar heat and release it throughout the night.

U. OF MARYLAND → WATERSHED



SOLAR PERGOLA ▶ As a backup to a 9.2-kw photovoltaic array on the south slope of its split-butterfly roof, the WaterShed has a solar pergola above its kitchen door. Six 220-watt panels shade a small deck. Micro-inverters convert DC current to AC current at each panel, eliminating excess wiring.

TEAM NEW YORK → SOLAR ROOF POD



MODULAR BLOCKS ▶ The City College of New York's Solar Roof Pod, designed to perch atop a four- to six-story structure, includes 8 x 5-foot building blocks that can be used as walls, windows, photovoltaic mounts or glass prisms. Owners can customize the 6½-inch-thick blocks' configuration.



☒ Students at Appalachian State found a way to boost solar thermal tubes' collection capacity by using a simple home-made rig and a very complex algorithm.

10-13

DIY SOLUTIONS

4 IDEAS TO TRY AT HOME

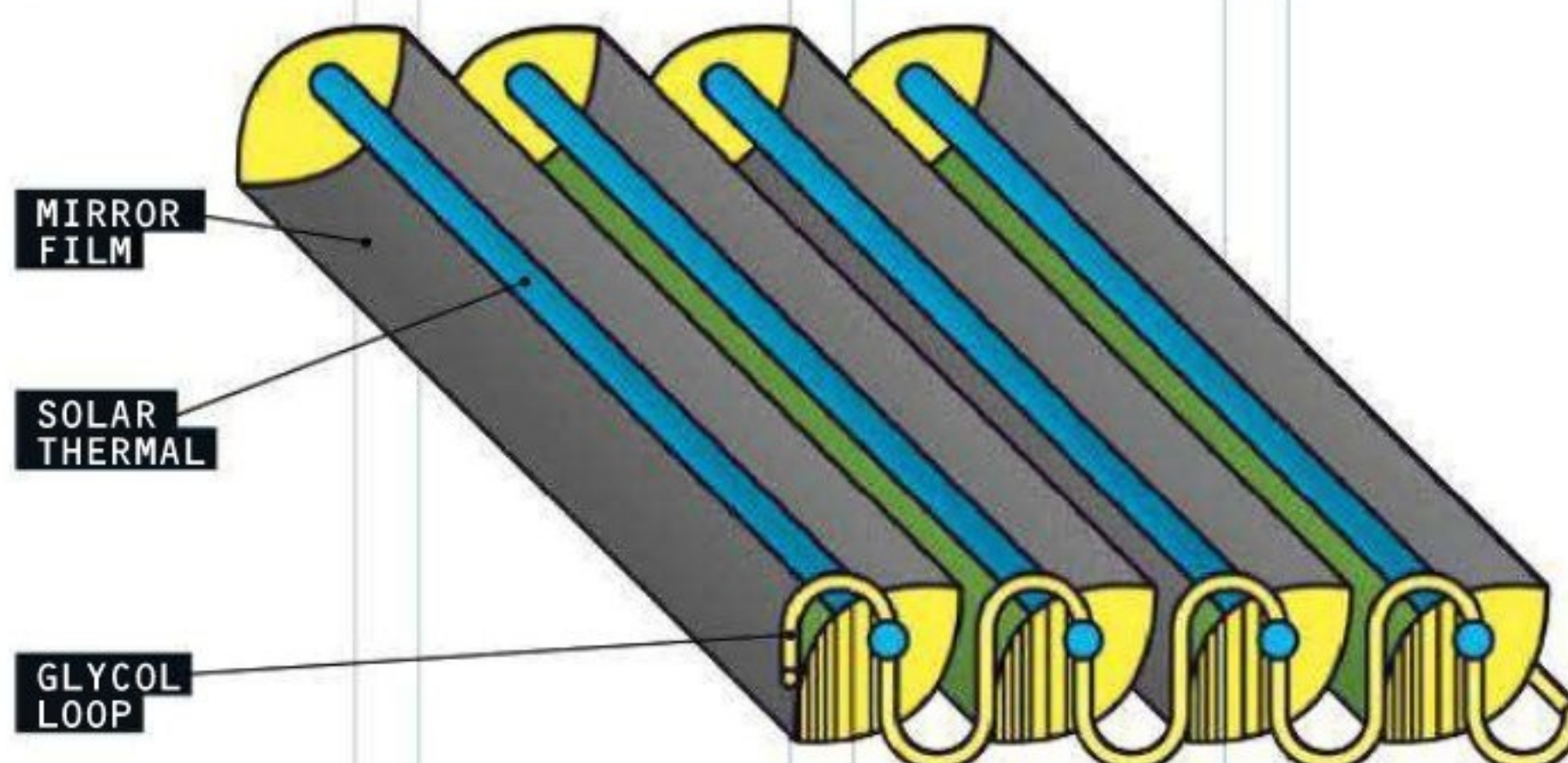
TRACK ENERGY USE ■ The eMonitor system by Intellergy, featured in Middlebury College's home, displays power consumption as an average or in real time. A top-five list reveals which appliances consume the most juice—info that can curb usage.

RECOVER HEAT ■ The Ohio State University's enCORE house uses an energy-recovery ventilator as part of its HVAC system. The device, which can be retrofitted onto ductwork, passes heat from outgoing indoor air into fresh air as it enters the home. This reduces the load on heating and cooling by capturing energy that would otherwise escape as exhaust.

GO NATIVE ■ Taking its cue from the Chesapeake Bay lowlands, the University of Maryland built a constructed wetland to manage rainwater and filter graywater. Residents can navigate the native landscaping on rot-resistant cooked-ash decking, which is fired in a kiln and similar to pressure-treated lumber.

AMP UP AN AWNING ■ Semitransparent Sanyo solar panels cast diffuse light on Appalachian State's porch. The partial shade is pleasing and powerful, plus the 42 panels collect UV on both faces to yield about 195 watts apiece.

APPALACHIAN STATE U. → THE SOLAR HOMESTEAD



CUSTOM REFLECTORS Mirror-lined troughs beneath an array of solar thermal tubes make each one more efficient at heating a glycol loop, which transfers energy to warm the Homestead's water. To mold the trough, students pressed flexible mirror film facedown on a length of 12¾-inch-diameter PVC pipe, clamped it in place with a pair of 2 x 4s on hinges, then spread fiber and epoxy on the rear to create a firm fiberglass backing. It's a simple process, but

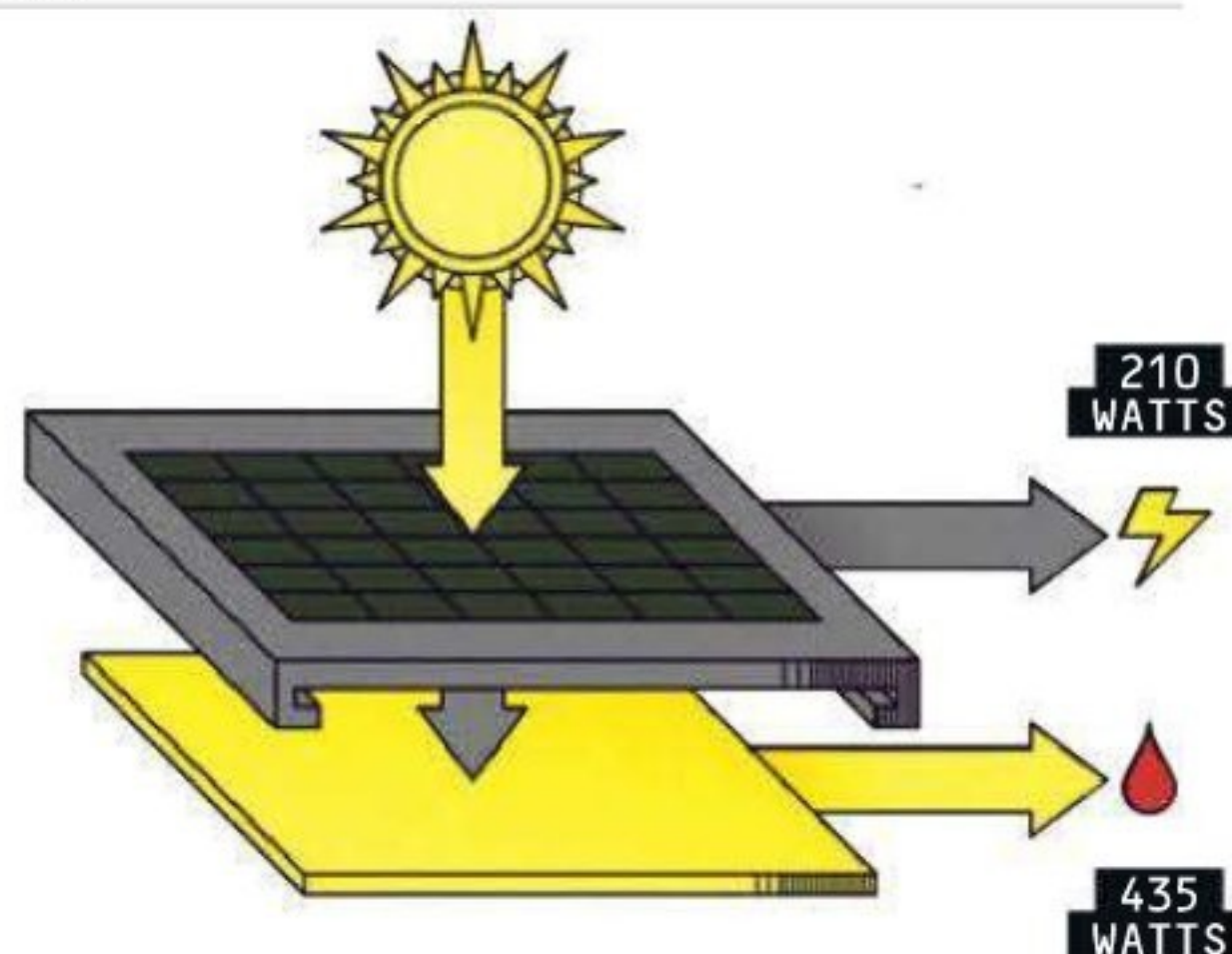
figuring out the exact angle of the trough's arc and its optimal distance from the tube took engineering physics graduate student Neil Rifkin two full semesters of hardcore number crunching. Parabola? Circle? The sun's position over Washington, D.C., in September? "Once I figured that out, building the reflectors was the easy part," he says. The resulting 6 x 16-foot thermal array is part of a solar skylight above the home's otherwise windowless mechanical core.

TEAM MASSACHUSETTS → 4D HOME

14

HYBRID PANELS

The Massachusetts College of Art and Design and the University of Massachusetts, Lowell, combined electricity-producing photovoltaic panels and water-heating solar thermal collectors in a single hybrid module. Normal PV panels' ½-inch silicon sandwich sits in a 1¼-inch aluminum frame. The 4D Home's SunDrum solar hybrid system fits a ¼-inch-thick flat-plate solar thermal collector into the extra space, leveraging it to heat domestic water while making the PV panel cooler and more efficient.



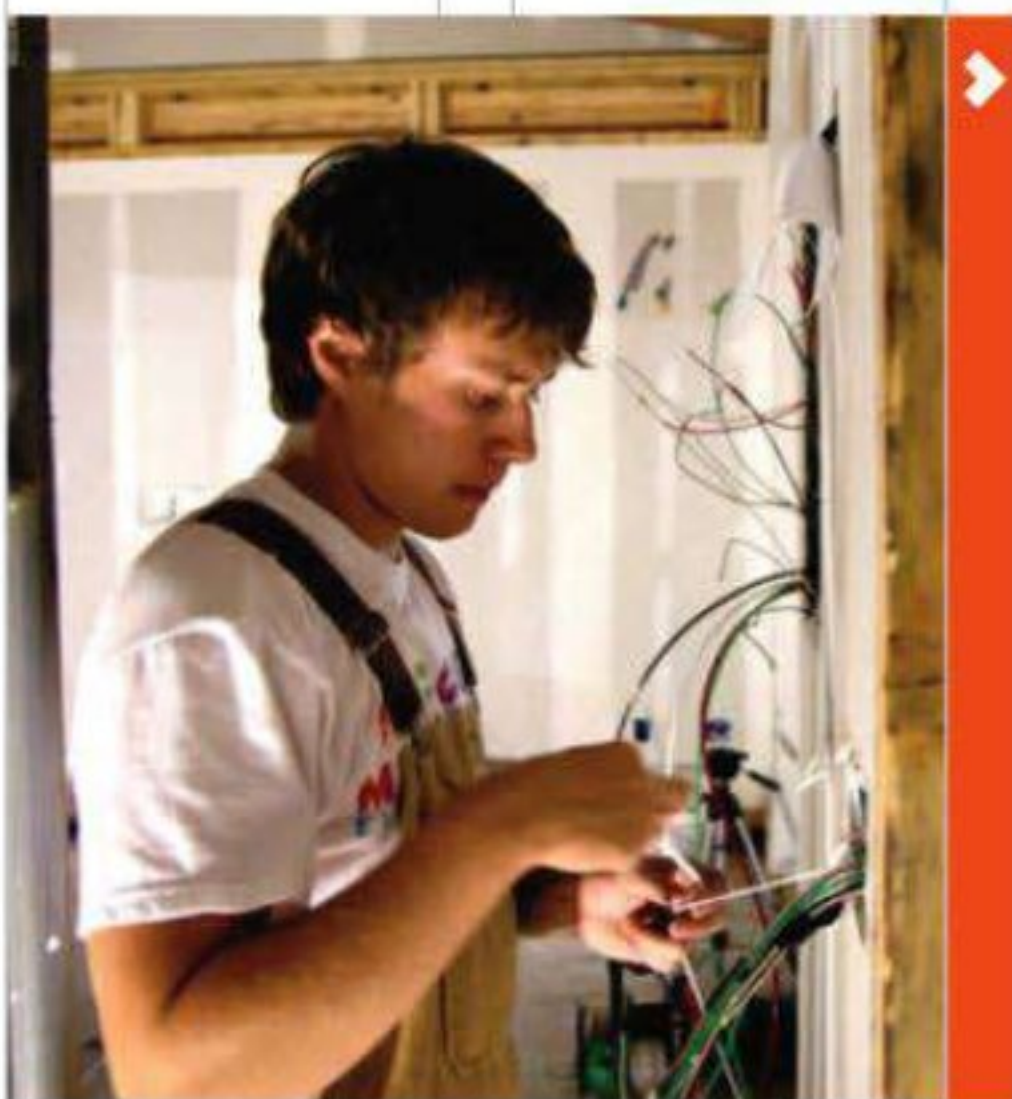
Counterweights help raise and lower hurricane-resistant, 450-pound shutters as quickly as closing a garage door.



15

FLORIDA INTERNATIONAL U. → PERFORM[D]ANCE HOUSE

☒ "Hurricane shutters are quite ugly," FIU project manager Andy Madonna says. His team's solution: 10 cantilevered, counterbalanced shutters that shade the house and porch. The shutters batten down to weather a storm, or just add privacy, in 15 minutes—an eighth of the time it takes to set up the hurricane shutters sold today. "We're trying to bring a new product to the market," Madonna says.

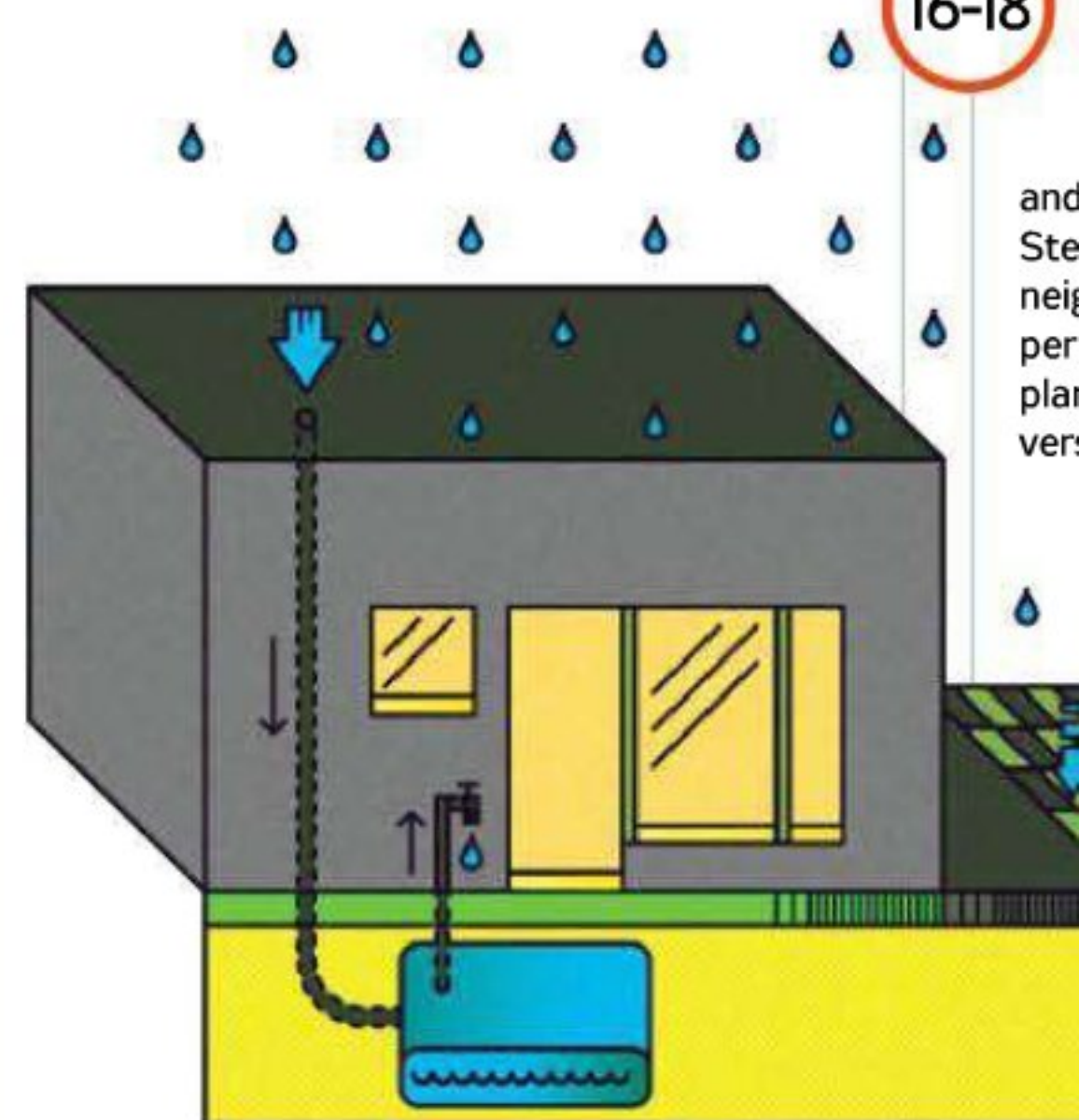


Senior electrical engineering major David Daily runs wire from the service panel to outlets and fixtures throughout the University of Maryland's WaterShed.



PARSONS • MILANO • STEVENS → EMPOWERHOUSE

16-18



RAIN WRANGLER To manage rainwater, the street curb's permeable pavers filter storm runoff into the soil. Rainwater that hits the roof feeds into a 1000-gallon underground cistern, accessed for garden use via a spigot. Surplus water feeds a sunken rain garden.

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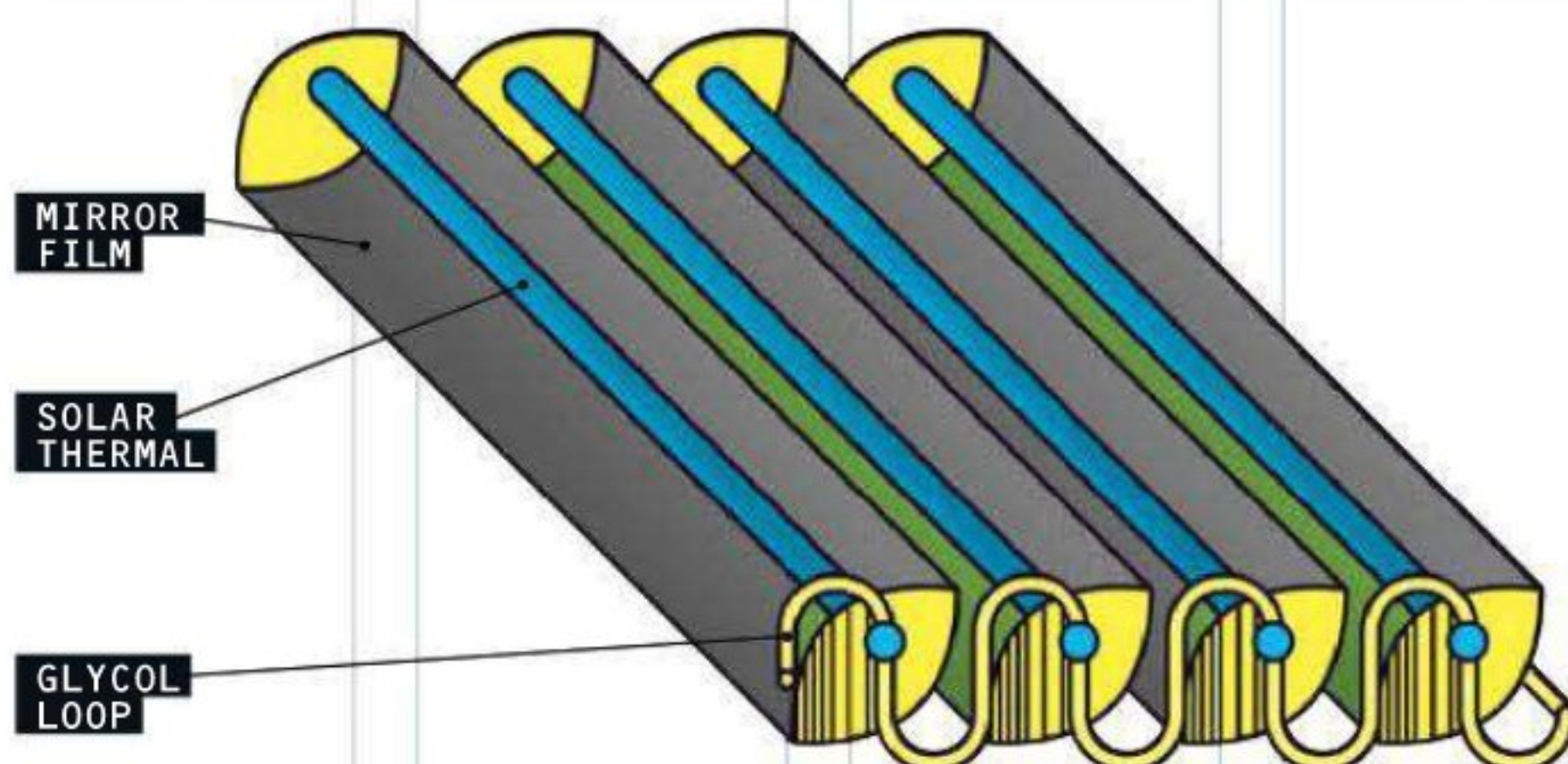
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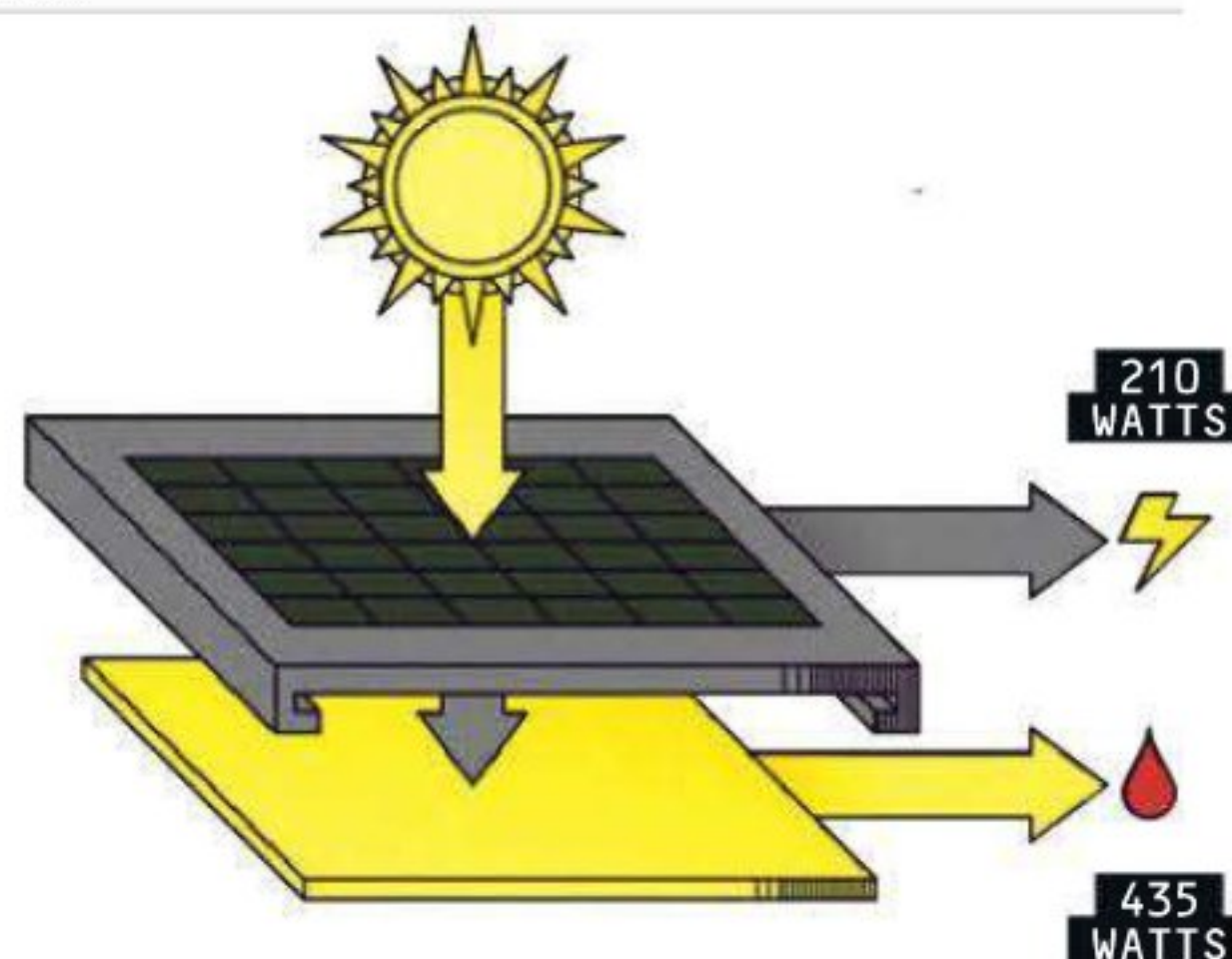
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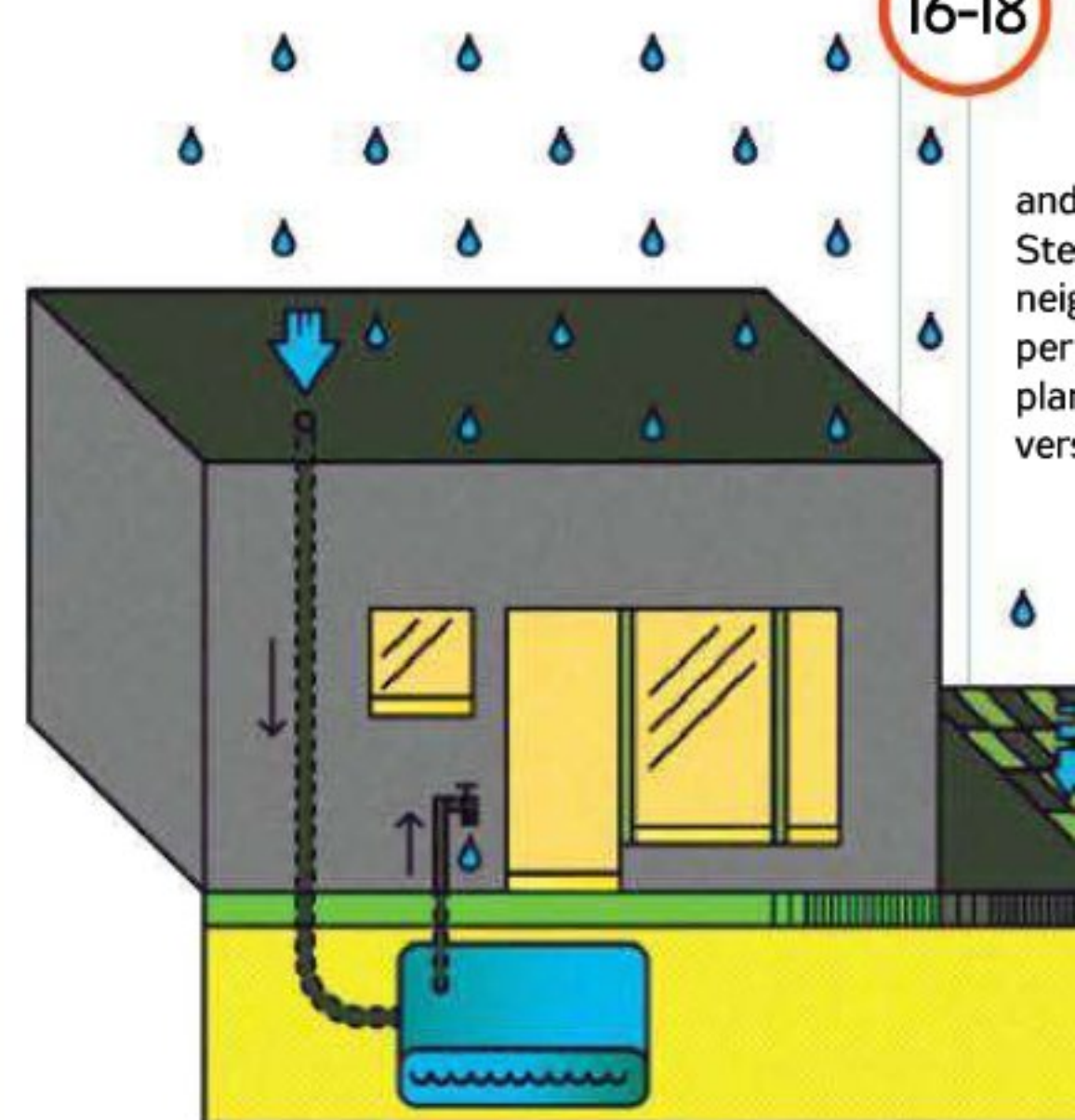


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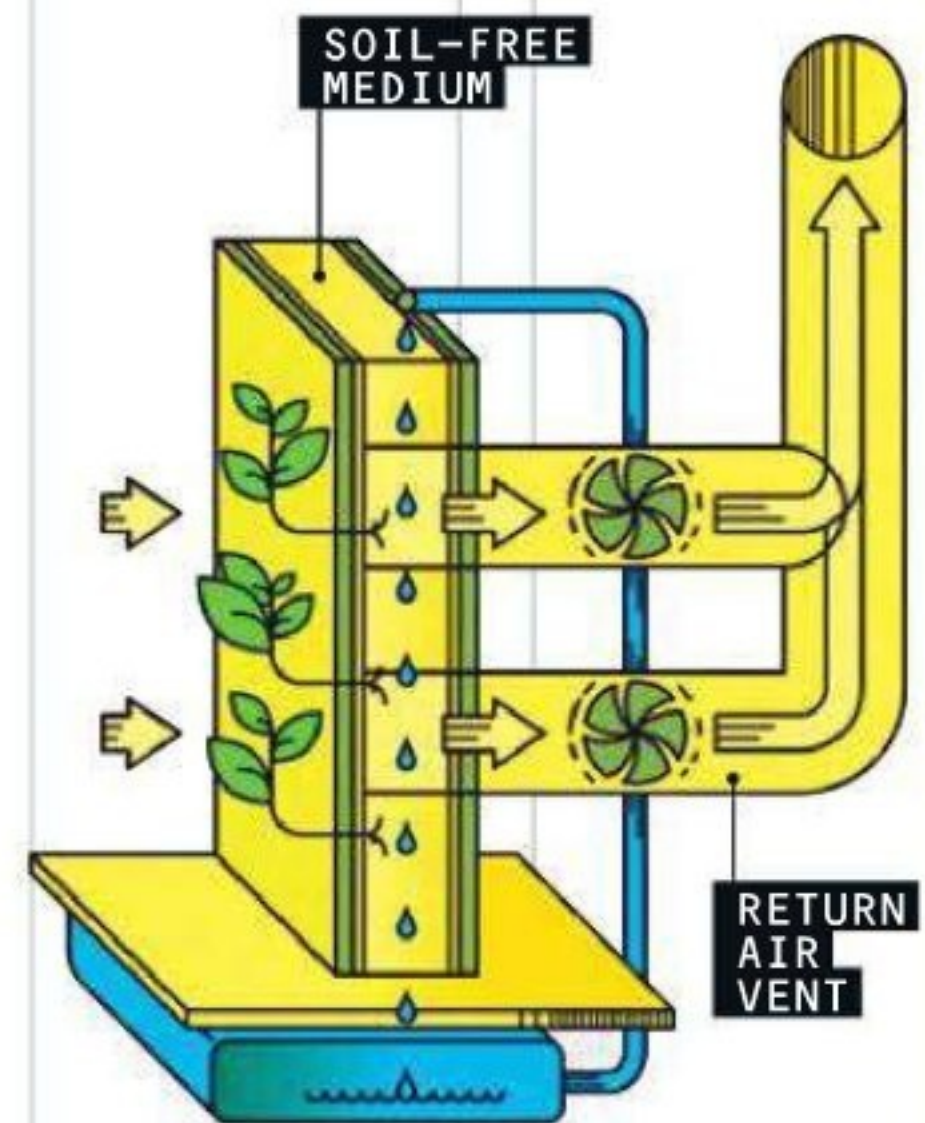
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19

PURDUE U. → INHOME

☒ Plant roots rid air of formaldehyde, benzene and other volatile organic compounds. Seriously. NASA proved it. Team Purdue adopted the science to design its vertical biowall.

FLORA FILTER A 2 x 6-foot vertical wall of plants cleans the INhome's air as it enters an HVAC return vent. Purdue student Kevin Rodgers designed the garden to grow in a soil-free, porous fabric medium fed by fertilizer-rich drip irrigation. "We use common plants like golden pothos and heart-leaf philodendron. Pass large amounts of air through the roots, and that's when you see benefits," Rodgers says.



MIDDLEBURY → SELF-RELIANCE

20



IMPENETRABLE WINDOWS ▶ To prevent energy loss through a window wall, architecture co-lead Joseph Baisch specified German Optiwin windows, which use a triple-pane design to resist heat transfer at a stout R-7 rating. The windows, plus R-42 walls and an R-74 roof, take insulation to the extreme.

U. OF TENNESSEE → LIVING LIGHT

21

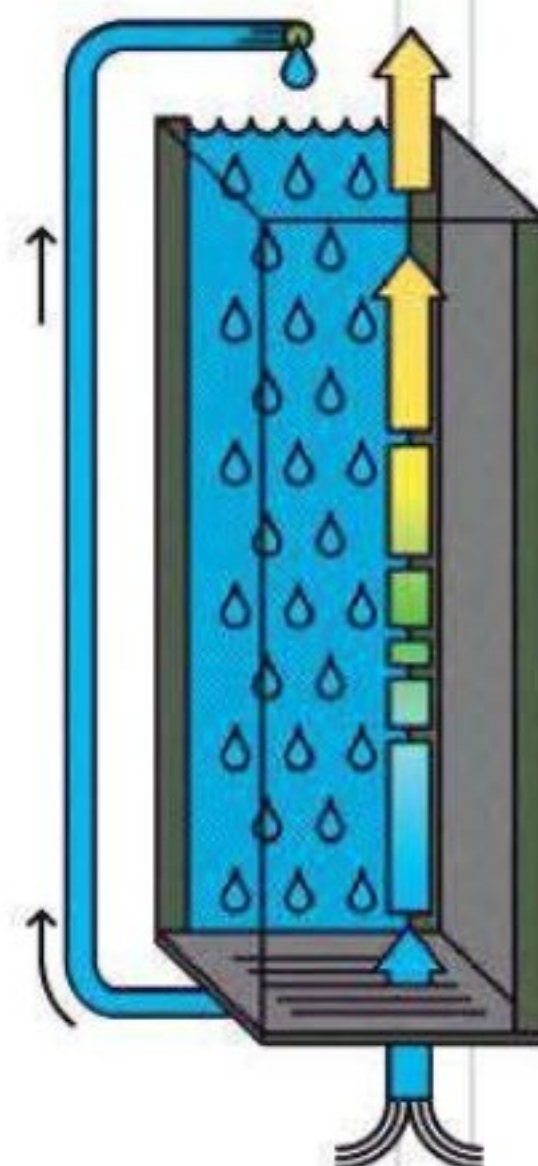


DUAL FACADE ▶ Two double-layer windows enclosing a foot-thick air gap cover the home's north and south walls. "We can maximize transparency, light and view without compromising the thermal envelope," project manager Amy Howard says. Automated blinds between the glass panels further reduce HVAC load.

AFTERLIFE Once the Solar Decathlon ends, many of the contest's houses end up sitting idle. But the team of Parsons The New School for Design, Milano (The Milano School of International Affairs, Management Urban Policy at The New School) and the Stevens Institute of Technology identified the D.C. neighborhood of Deanwood as the ideal permanent venue for its Empowerhouse. The team plans to show an 860-square-foot competition version of the house on the National Mall. After the Decathlon, that home will combine with a second building to create a 2700-square-foot two-family dwelling.



LANDSCAPE DESIGN The team chose to surround its house with American hornbeam trees because their slight stature won't block the sun from reaching a 5-kw solar panel array. Plants such as hydrangeas and switchgrass filter heavy metals, removing them from the garden's soil.



TEAM FLORIDA → FLEX HOUSE

☒ To manage humid air using one-third the electricity required by an air conditioner, students from Florida State University designed a liquid-desiccant waterfall.

22

DRIZZLING DEHUMIDIFIER "It's basically salt water," Florida State mechanical engineering graduate student Jon Pandolfi says about the calcium chloride blend flowing down a 7.5-foot-tall acrylic sheet. Visible in the house, the sealed chamber doubles as an HVAC duct. Humid outdoor air enters the duct, then the desiccant collects moisture. Combined with an energy-recovery ventilator, which heats or cools air but doesn't dry it, the system beats the swamp heat without wasting wattage. **PM**

Adventure-Touring Bikes

GOOD TO

PRISTINE SHORELINES, OLD LUMBER TOWNS, ABANDONED COPPER MINES, VAST WILDERNESS—MICHIGAN'S REMOTE UPPER PENINSULA IS PRIME FOR EXPLORATION. AND THE BEST WAY TO SEE IT ALL—BE IT VIA THE COMFY BLACKTOP OR TREACHEROUS DIRT TRAILS—IS ON AN ADVENTURE-TOURING BIKE. ROAD TRIPS SHOULD ALWAYS BE THIS FUN.

by **Sam Smith**

photographs by **James Minchin**



AFTER 2 HOURS EXPLORING AN ABANDONED COPPER MINE, EMERGING INTO THE AFTERNOON SUN

Built to handle virtually any terrain, adventure-touring motorcycles are the ultimate road-trip vehicle. Here, the group crosses a converted train trestle on their way to Houghton, Mich.

dialed our pupils down to pencil points. We were fascinated by the descent into upper Michigan's underground history, but we were on a motorcycle trip and were eager to log more miles in the aboveground present. We were three days into our journey, roughing out an itinerary on the fly with nothing more than a map, a rough sense of direction and the kindness of strangers.

We had spent most of our time on paved roads, but we were curious about the local dirt. "Is there a decent off-road trail around here anywhere?" we asked the owner of the Adventure Mining Company, a 37-year-old engineer named Matt Portfleet. He ferries tourists around the mines with two ex-Swiss Army Pinzgauer



PM TEST-DRIVEN ++

4WD troop trucks, so we figured he would know.

"How near were you thinking?" he asked. "Because if you turn left at the end of this parking lot, the trail will take you about 75 miles off-road almost into Houghton."

No matter which route we took, there would be a hotel room, a shower and a happy hour waiting for us in town. Taking the road would get us there in 2 hours; the trail would take at least 4.

Naturally, the trail won.

We had our choice of routes, thanks to the motorcycles we were riding. Adventure-touring bikes are motorcycling's SUVs: dirt-and-pavement Swiss Army knives with long-travel suspension, hard-wearing bodywork and torquey powerplants. These bikes aren't dirt machines per se, but they're capable off-road, especially with street-legal

knobby tires. They can also easily rip off an 800-mile day cruising the highway. Buy one, the thinking goes, and you can ride to Panama and back without getting sore. Or tear off into the woods of Michigan's Upper Peninsula and indulge, as we did, in a few days of unplanned exploring.

If statistics are any judge, this kind of motorcycling has pretty wide appeal. Sales for adventure tourers, also known as dual-purpose motorcycles, rose nearly 25 percent in the first quarter of 2011. It used to be that the BMW R1200 GS ruled this category, but there is now a host of new players in the game.

Adventure tourers run the gamut from \$6000 650-cc single-cylinders to \$15,000 1200-cc monsters weighing 600 pounds or more. For our journey, we gathered five new motorcycles, each representing a different way to explore on two wheels: a BMW F800 GS, a Kawasaki KLR650, a Suzuki V-Strom 650 ABS, a Triumph Tiger 800XC and a Yamaha Super Tenere.

Why Michigan? First off, it's a big place; the state encompasses two enormous peninsulas, each of which is culturally distinct enough to be its own country. Combined, they hold around 3200 miles of off-road-vehicle trails. Second, with three Great Lakes and

3288 miles of shoreline, there's a lot of pristine space to get lost in.

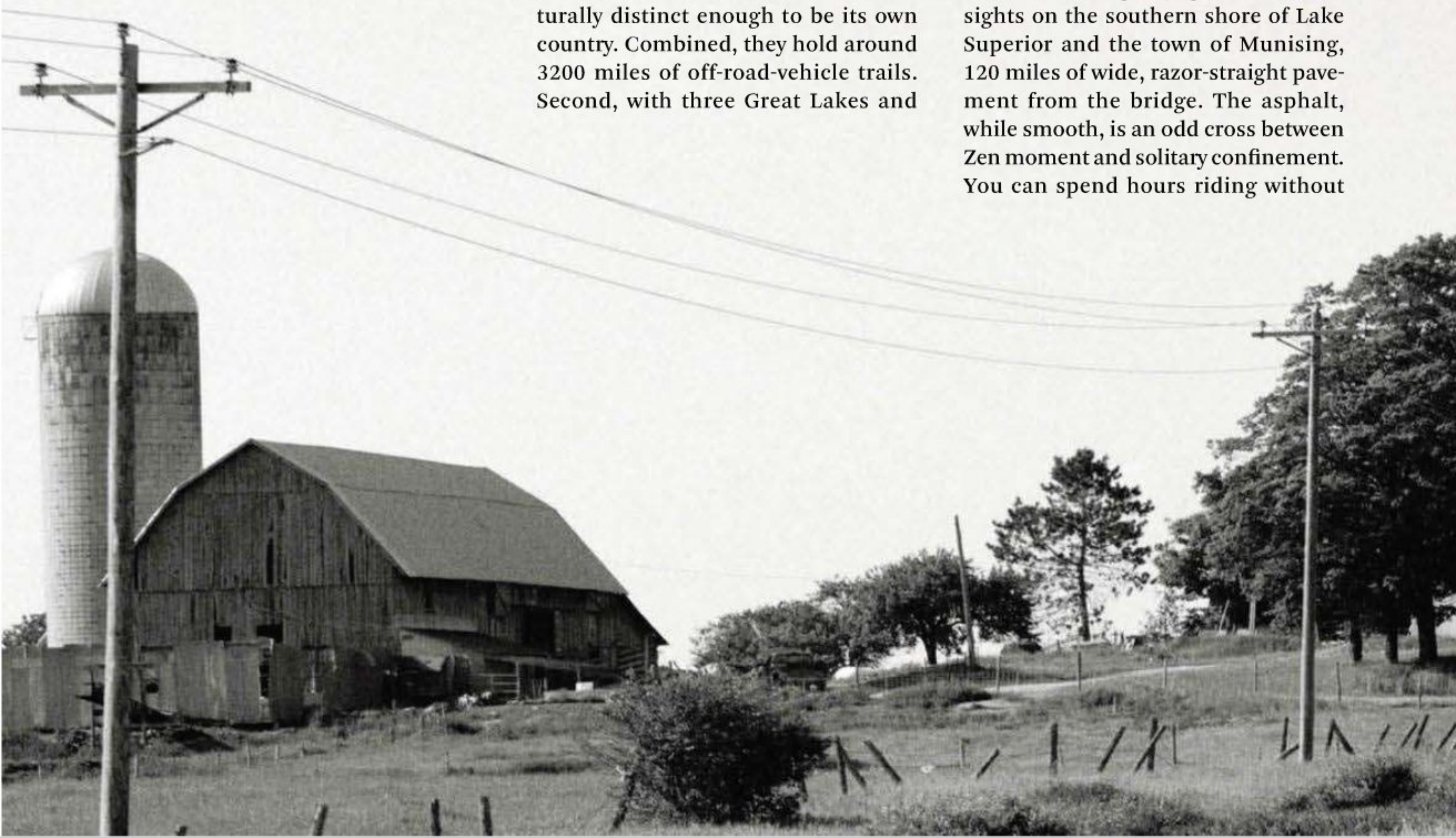
When our group bombed out of Ann Arbor, Mich., one June morning, sun blazing and bikes freshly washed, we had no idea we were headed to the depths of a copper mine.

IF YOU'RE TRAVELING to Michigan's Upper Peninsula (locals just call it the U.P.), you'll spend a lot of time crossing the rest of the state. Ann Arbor is 280 miles from the 5-mile-long Mackinac Bridge, which connects the state's two land masses, and on a map the roads look like graph paper. The counties in Michigan's top half are hilly, sparsely populated and covered in a rolling carpet of trees and wildflowers.

The bridge crossing—narrow, windy and nerve-racking even in pleasant weather—is a rite of passage for Michiganders. An engineering marvel, the 26,372-foot-long, 552-foot-tall Mackinac is the third-longest suspension bridge in the world and the longest in the Western Hemisphere. When it opened in 1957, it marked the end of the slow ferry ride across the Straits of Mackinac, the narrow slice of water between the state's two peninsulas.

In the interest of gaining seat time and not wasting daylight, we set our sights on the southern shore of Lake Superior and the town of Munising, 120 miles of wide, razor-straight pavement from the bridge. The asphalt, while smooth, is an odd cross between Zen moment and solitary confinement. You can spend hours riding without

Michigan's Upper Peninsula offers miles and miles of empty picturesque roads like this one.



seeing another car or a curve in the road. It's like Nebraska with pine trees. All the bikes easily cruised at 70 mph, but some were more skilled at this mindless task than others. On one end, the Kawasaki's relatively low-powered single-cylinder engine annoyingly buzzed and let the rider know there wasn't much speed left to be tapped. The Yamaha, however, has a sail-size fairing and plenty of power in reserve—a perfect tool for covering distance.

The U.P.'s towns are all ghosts of what they once were; a century ago, the peninsula was chock-full of thriving fishing communities, active copper mines and sawmills. Now dried-up vestiges of the original settlements—Canadian-accented vowel jumbles such as Escanaba and Ishpeming—dot the landscape, while vacation homes line the coast. Munising, an old lumber town in a sheltered bay, is the jumping-off point for the shoreline's dramatic cliffs and the 114-square-mile Pictured Rocks national park.

You can rent a room in Munising without too much trouble; the town's population is a whopping 2983, and motels are on almost every corner. We picked a small one on the town's harbor, surrounded by hundred-year-old buildings and a Dairy Queen with a mile-long line. The air was that impossible blue you get only in northern summers, the water of Lake Superior cold enough to numb your toes. We ate our weight in buttery local lake trout,



BMW
F800 GS

As-tested price **\$12,900**
Engine/trans **798-cc liquid-cooled parallel twin/6M**
Rear-wheel horsepower **78**
Weight (pounds) **526**
Suspension travel, front/rear (inches) **9.0/8.5**
Seat height (inches) **33.5 to 34.6**
Fuel-tank capacity (gallons) **5.2**
Fuel economy (mpg) **47.90**

THE GOOD

Feels slim like a dirt bike, and off-road it rips with such agility that you'd never guess that it outweighs its closest rival in this test, the Triumph. Barky exhaust gives it a rebellious aura. Embarrasses many bikes on curvy roads and outruns most cars. The suspension has the same uncanny combination of suppleness and sharp handling as BMW's road cars, so the rider feels connected to the road, not simply on top of it. High-quality switchgear survives contact with the ground. So capable overall, we have to wonder why anyone would drop the extra dough on its big brother, the 1200.

THE NOT-SO-GOOD

Narrow, hard seat could double as a fence rail. Trip computer hard to operate with a gloved hand. A touch of engine vibration.

THE BOTTOM LINE

Straddles the line between dirt and street better than just about any other bike.



Kawasaki
KLR650

As-tested price **\$6149**
Engine/trans **651-cc liquid-cooled single/5M**
Rear-wheel horsepower **37**
Weight (pounds) **423**
Suspension travel, front/rear (inches) **7.9/7.3**
Seat height (inches) **35**
Fuel-tank capacity (gallons) **5.8**
Fuel economy (mpg) **42.60**

THE GOOD

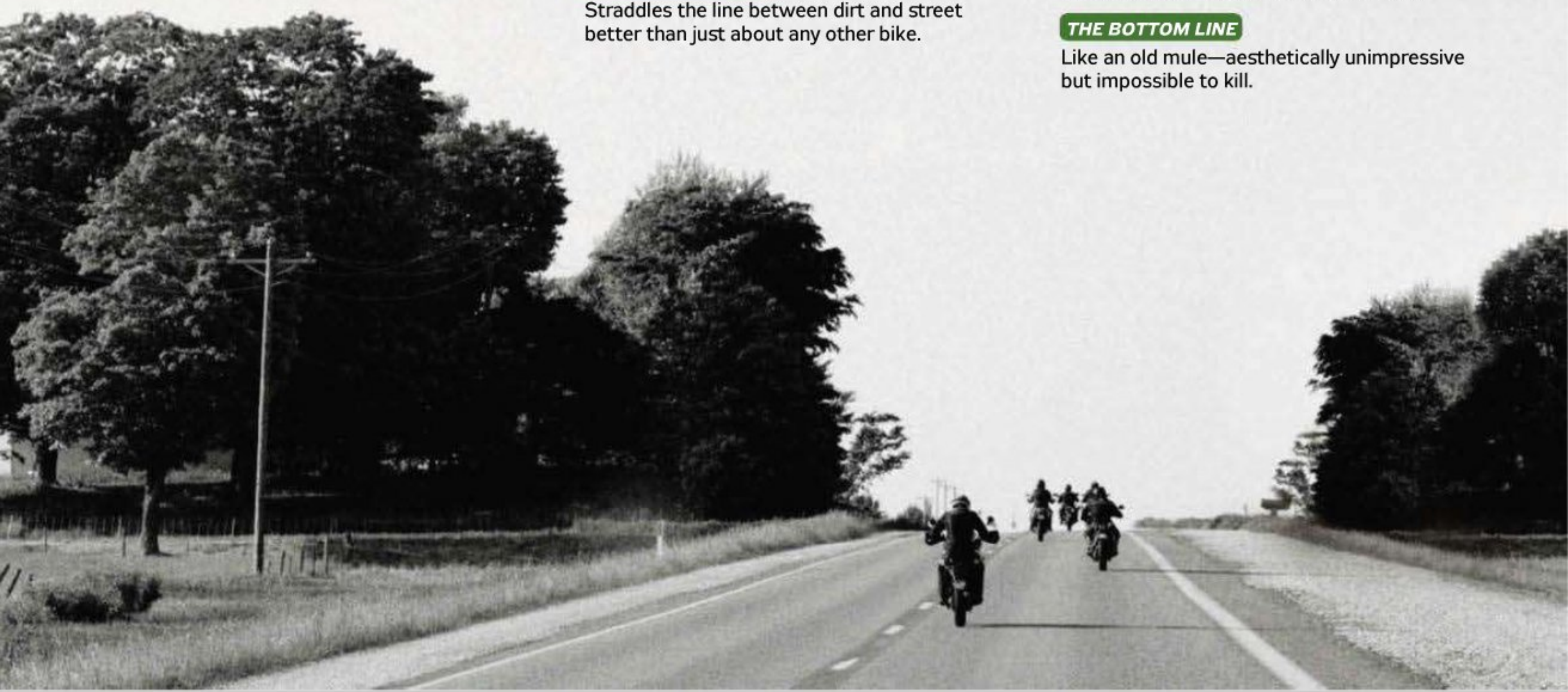
Mechanically simple—it still breathes through a carburetor—so, of the five bikes, you have the best shot at fixing this one trailside. Its comparatively light weight made it the easiest to wrestle through tight, rocky trails. It has just enough power to cruise at 80 mph, but don't ask for more. Engine has decent low-end grunt but would probably benefit from lower gearing. Suspension does an admirable job of absorbing big off-road bumps. The low starting price means there's money left over to indulge in the huge KLR aftermarket, a benefit of this bike's age. It first appeared in 1987.

THE NOT-SO-GOOD

Earned the trophy for both the slowest and the thirstiest bike. Engine shake puts hands and feet to sleep. Exhaust note sounds like a bleating goat, which is a little awkward.

THE BOTTOM LINE

Like an old mule—aesthetically unimpressive but impossible to kill.





Suzuki
V-Strom 650 ABS

As-tested price **\$8099**
 Engine/trans **645-cc liquid-cooled V-twin/6M**
 Rear-wheel horsepower **62**
 Weight (pounds) **470**
 Suspension travel, front/rear (inches) **5.9/5.9**
 Seat height (inches) **32.3**
 Fuel-tank capacity (gallons) **5.8**
 Fuel economy (mpg) **51.00**

THE GOOD

Don't dismiss the V-Strom as yet another UJM—universal Japanese motorcycle. While stylistically challenged compared with the BMW and the Triumph, the Suzuki has won many praises for its overall competence. The V-twin is lacking displacement, but it's sewing-machine smooth and happy to rev, and has plenty of moxie. We appreciated the V-Strom's low seat height in the dirt, and the soft cushion and fairing made passing highway miles effortless. In terms of value per dollar, it's one of the best on the market. As one rider prepared to climb aboard, he said, "Helloooo, sweetie," a sentiment shared by all.

THE NOT-SO-GOOD

It's missing some creature comforts, such as outlets for a heated vest. Lacks the visual and audible character that makes motorcycles, you know, badass.

THE BOTTOM LINE

A terrific, easy-to-ride starter bike, yet it's got enough get-up-and-go to hold our interest.

drank beer named after sunken Superior freighters (Great Lakes Brewing's Edmund Fitzgerald Porter tastes of coffee and impressive seamanship) and generally toasted the art of modern motorcycle design.

LEAVING MUNISING the next morning, we made for Marquette, the U.P.'s largest city, about 50 miles away. Marquette houses Northern Michigan



Triumph
Tiger 800XC

As-tested price **\$11,799**
 Engine/trans **799-cc liquid-cooled I3/6M**
 Rear-wheel horsepower **82**
 Weight (pounds) **481**
 Suspension travel, front/rear (inches) **8.7/8.5**
 Seat height (inches) **33.2 to 34.0**
 Fuel-tank capacity (gallons) **5.0**
 Fuel economy (mpg) **42.70**

THE GOOD

A bike full of superlatives—fantastic power, wonderful turbine-like exhaust sound, techno-industrial styling that looks good and sportbike road handling. Wonderfully responsive chassis, and the tank is high enough that you can lie on it and tuck behind the meager fairing. Buttery gearbox shifts cleanly, and the throttle response is thrilling—it's like there's no flywheel connected to the engine. While its heft is a hindrance off-road, the bike's balance makes it better suited off the pavement than we expected. Sure, it's pricey, but it delivers.

THE NOT-SO-GOOD

Slurps fuel and has a smallish tank, so make sure you know the gas station situation before getting too lost. Some thought the fairing directed the wind right at the rider's helmet.

THE BOTTOM LINE

With the right tires, we wouldn't hesitate to run some mud, but it prefers pavement.

University, but its chief attractions are a quiet harbor, a 19th-century downtown and ore-loading docks so big they dwarf the massive ships that sidle up to them. I wanted to see the latter because I'm a sucker for monster engineering; PM senior automotive editor Mike Allen wanted to see them because his father was a Great Lakes freighter captain. Throughout our trip, he regaled us with tales of men doing manly historical-ship things like navigating



Yamaha
Super Tenere

As-tested price **\$13,900**
 Engine/trans **1199-cc liquid-cooled parallel twin/6M**
 Rear-wheel horsepower **90**
 Weight (pounds) **574**
 Suspension travel, front/rear (inches) **7.5/7.5**
 Seat height (inches) **33.3 to 34.3**
 Fuel-tank capacity (gallons) **6.0**
 Fuel economy (mpg) **43.00**

THE GOOD

Wickedly quick—the fastest bike in the group—and touring-bike-stable on the highway. The supple suspension turned cratered roads smooth. "I'm aiming for potholes, just for the sport of it," said one tester. Lots of useful, well-engineered details such as an adjustable seat and windscreen, a shaft drive and traction control. Linked brakes with ABS mean a simple squeeze of the front-brake lever in a panic will stop the bike in short order. Optional saddlebags have clever, easy-to-use mounts. If we had three days to ride to California, this would be the bike.

THE NOT-SO-GOOD

On the dirt, it's like riding an athletic woolly mammoth compared with the other bikes. Engine vibrates at high revs. One tester said the exhaust sounds like the muffler was "made out of old soup cans."

THE BOTTOM LINE

Promises adventure on all terrains, but too heavy to really deliver off-road.

life-threatening storms in the middle of the night. Coincidentally, these stories emerged whenever I began to think that motorcycling was making me brave and awesome. As my dad used to say, perspective is everything.

Our trail to Houghton traces back to a plate of scrambled eggs in a diner in Munising. Over breakfast on the second day, we were pondering where to go when the waitress mentioned the mines. The U.P. boasts one of the



PM auto editor Larry Webster (left) and author Sam Smith consult a Department of Natural Resources map for the nearest off-road-vehicle trail. Below: The BMW F800 GS soaks up the bumps on an abandoned railroad right-of-way.



world's largest copper veins, and mines have existed on the peninsula's western half, Copper Country, since prehistoric times. Some of them are played out, but many have simply become too expensive to be kept running. Owners often fall back on tourism.

Portfleet's mine is near the hamlet of Greenland. Portfleet and his wife, Vicky, bought the 160-year-old, 1300-foot-deep mine in 2005. We first met him in the parking lot, where he spotted the bikes and came to chat.

"I've been thinking about getting a BMW GS," he said. "I have a lot of friends who want sportbikes, but you can't really use 'em up here. These bikes make sense on this kind of terrain." His tour of the mine proved to be the kind of fascinating, history-drenched thing that you always mean

to do on vacation but never actually get around to doing. Amazingly, the mine was originally excavated by candlelight using sledgehammers and broom-handle-size steel spikes. Portfleet allowed that if we had more time, we could rappel down one of the deeper shafts—he offers a tour that does just that—and head into the mine's guts.

"I didn't want an office job," he said. "This won't make me rich, but it's fun."

Then he pointed us toward the dirt.

THIS IS THE BEST PART about these motorcycles: You can ride wherever, whenever, sometimes just to see where a road goes. Following Portfleet's tip, we blasted onto the trail that once served as a railroad right-of-way. From the parking lot of Adventure Mining,

the trail disappeared into a series of deep valleys. The trail to Houghton—itsself an old mining camp that has evolved into a college town—leads through a series of gravel switchbacks and gorge-spanning railroad trestles. At one point we popped out of the forest, grabbed fresh pasties (an up-north meat pie, not unlike a supersize Hot Pocket) at a gas station and dove back onto 70-mph dirt straights. The kicks kept on coming.

All of us fell—it's almost impossible not to—but we were well-gearred-up for both bad weather and close contact with the terrain. We wore armored all-weather riding gear from Rev-It, Alpinestars and BMW. With removable thermal and rain liners, we were warm and dry regardless of the weather.

One of our more experienced riders remarked that he'd never gone so fast off-asphalt before. Five miles later, we were standing on the pegs and poking through knee-high grass in first gear. A few hours after that, exhaling dust from our nostrils, we were checking into an old-style motel on Houghton's main drag and having the proprietress introduce us to her duffel-bag-size house cat.

Funny thing about dirt: You cover yourself in it, people assume you're trustworthy. The U.P.'s vaguely reserved Scandinavian nature was tempered by the extreme friendliness that the bikes brought out in the locals.

In the end, though, for all we felt at home, the PM crew may as well have been on the moon. We ate random regional food that most of us couldn't pronounce. (Do you know how to say "cudighi" or "pannukakku"?) We stood inside a mountain and reflected on our trip in the time-travel blackness of a copper mine; we rode over a railroad trestle spanning a 200-foot ravine. Best of all, we stayed in clean hotel rooms every night, got satisfyingly filthy during the day and discovered a strangely foreign American land within spitting distance of civilization. All of it impromptu. **PM**

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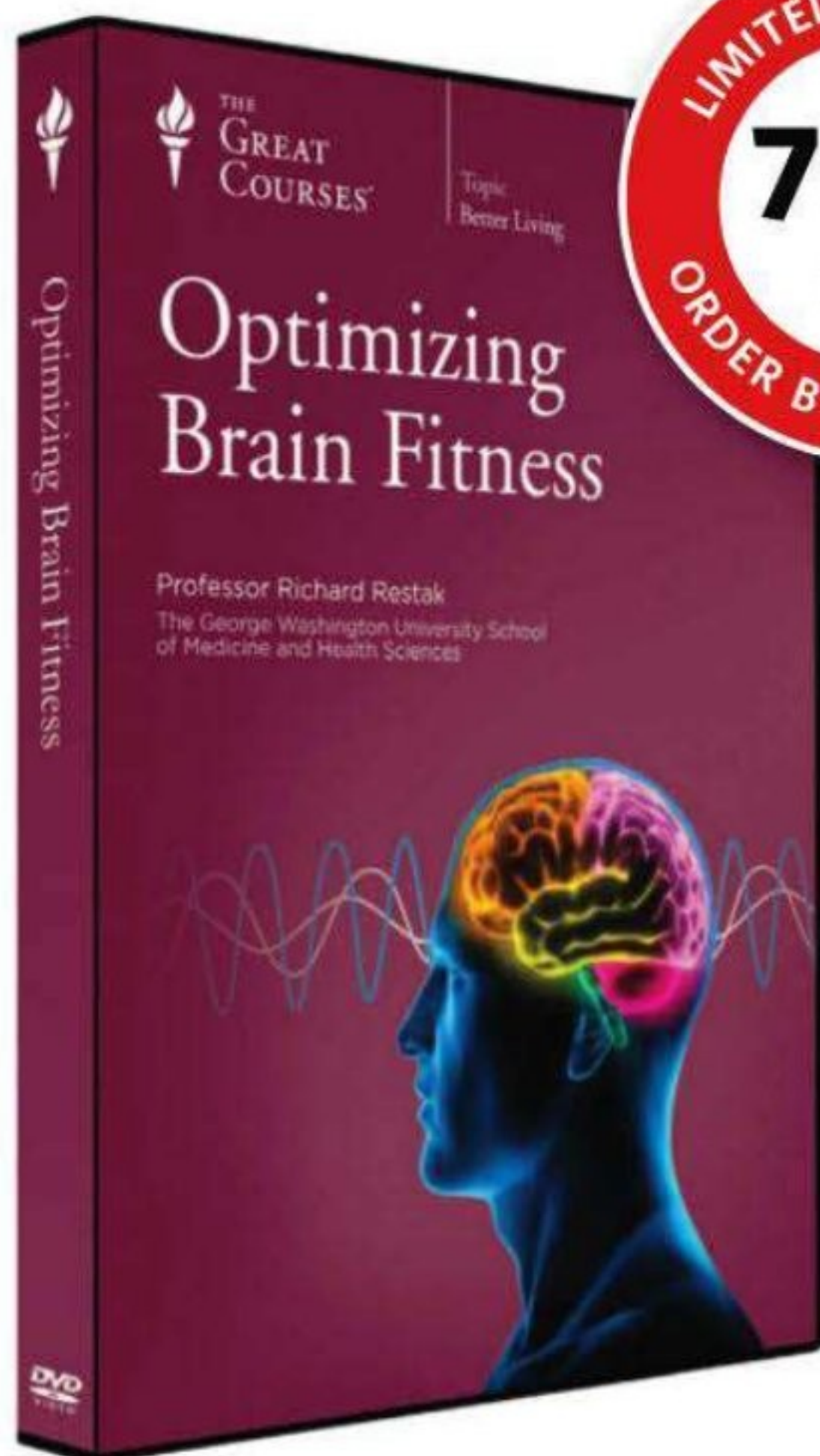
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DIY

Tech

ISO    A S

Shooting professional-looking photos takes more than a fancy digital single lens reflex camera (DSLR). Knowing how to harness its aperture and shutter controls, flash intensity, light metering and ISO will help bring your photography skills up to the level of your gear.

Beyond Automatic

FULL AUTO MODE IS FINE—MOST OF THE TIME. BUT YOU CAN TAKE BETTER PICTURES BY USING FIVE KEY MANUAL CONTROLS. BY DMITRI ALEXANDER

➡ **The latest digital SLR cameras** employ sophisticated light sensors and composition-analyzing algorithms to routinely nail correct exposures in full auto mode. Yet amateur DSLR photos often look no better than shots from a run-of-the-mill point-and-shoot. The reason, explains photography instructor Bryan Peterson, lies in appreciating the difference between a “correct” exposure, mean-

ing one that’s well-lighted and not blurry, and a “creatively correct” exposure, meaning that you actually *like* how the picture looks. To achieve the latter, sometimes you have to say goodbye to your friend Full Auto.

Exposure is determined by three key settings—aperture, shutter speed and sensitivity to light, or ISO—as well as by how the camera meters light and how intensely the flash is fired. For any given scene, there are dozens

INSIDE



HOT GADGETS + OVERPRICED PHONE PLANS + NEW ANTIPIRACY REGS



GET THAT NEW WAVE SOUND

Build Your Own Retro Analog Synthesizer!



There are a lot of great beginner electronics projects, but this one is a true cult classic. The “Stepped Tone Generator” first appeared in *Engineer’s Notebook: Integrated Circuit Applications*, written by the champion of amateur science, Forrest Mims, and published by RadioShack in 1980. It later came to be known as the “Atari Punk Console” (APC) for its sonic similarity to the early video game system.

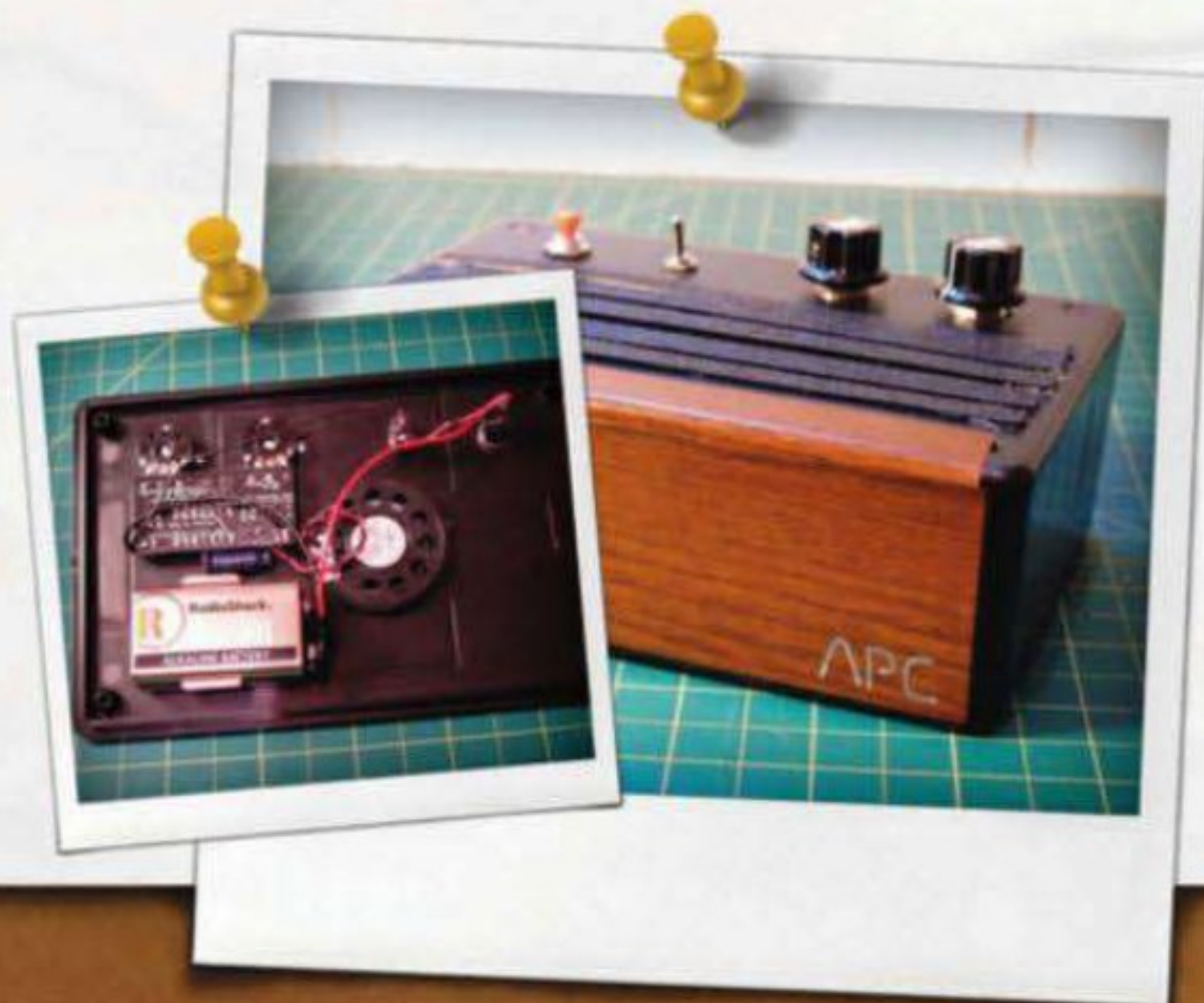
At the heart of the APC is an integrated circuit called the 556 (actually a doubled-up version of another common IC, the 555). The circuit generates a square wave, which gives it its distinctive sound. The pitch is controlled by a pair of potentiometers—variable resistors with knobs that can be played like a musical instrument. An optional switch or momentary push button can be included in the circuit to turn the tone on and off. The APC can play through its own internal

speaker, or the audio signal can be sent to an external amplifier or headphones through an output jack.

Like many popular DIY projects, the APC has been “hacked” over the years. For example, one can replace the potentiometers with photoresistors, and play the mini-synth with light. People have also come up with some creative packaging ideas, such as using an old video game joystick as an enclosure.

I built my own APC in just a few minutes using parts available at RadioShack. One of the handy features of RadioShack’s universal solderless breadboard is that you can plug an integrated circuit like the 556 right into the center of the board, which makes it easy to connect other components to the IC’s pins.

Following a circuit diagram I found with a quick Internet search for “Atari Punk Console,” I inserted the capacitors, resistors, speaker wires and the 9V connector into the breadboard. I had to solder my own lead wires onto the



potentiometers, as well as to the push button. A few jumper wires were required to complete the circuit. I attached the knobs to the potentiometer posts, and attached the potentiometers and the speaker to the breadboard with some double-sided tape. The push button fit nicely into one of the holes in the board intended for the terminal posts (those weren't needed for this project). Finally, I plugged in a 9V battery and was ready to rock!

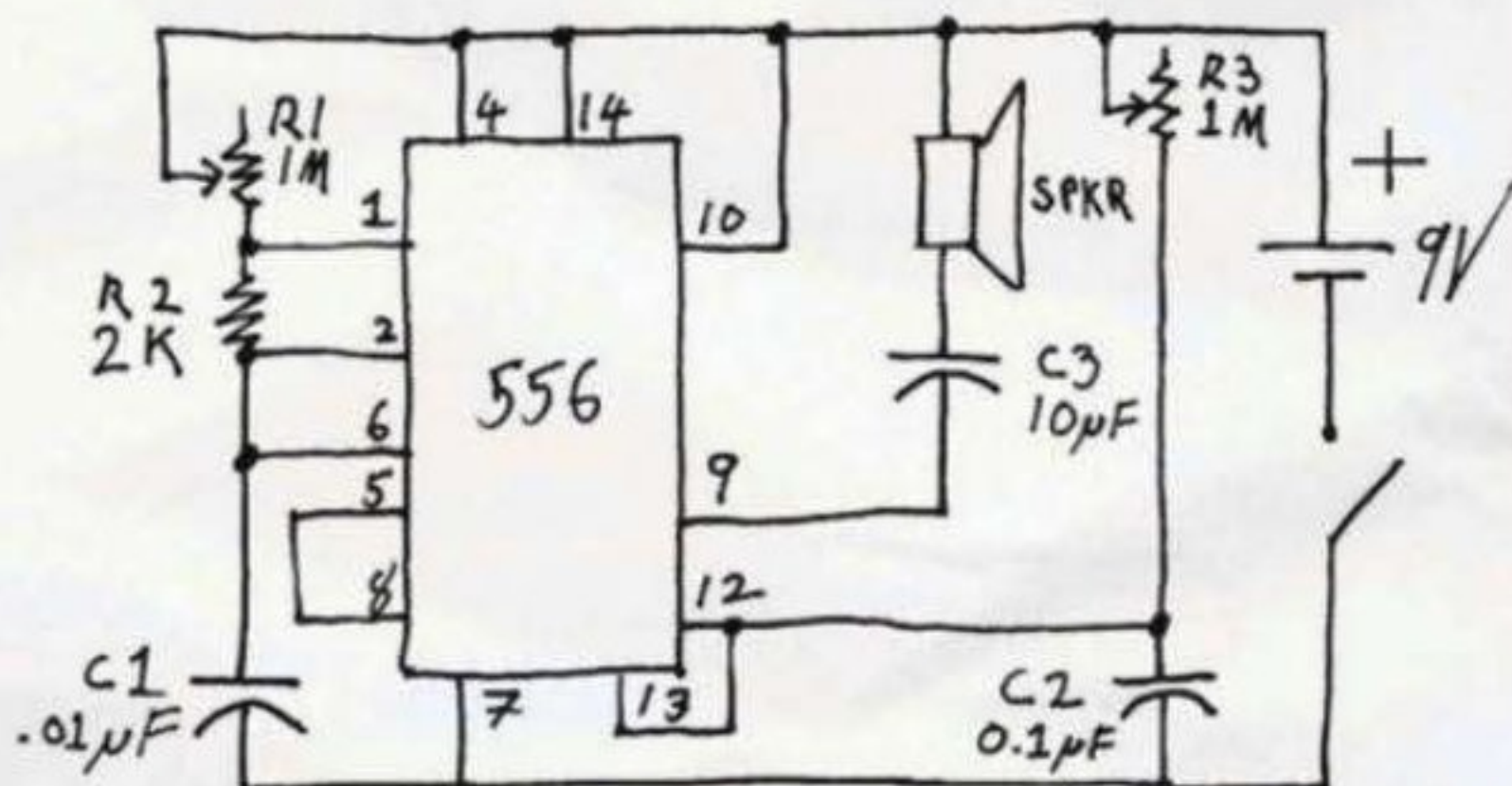
About the author:

Ken Murphy is a programmer, musician, artist, author and tinkerer living in San Francisco.

PARTS (All available at RadioShack)

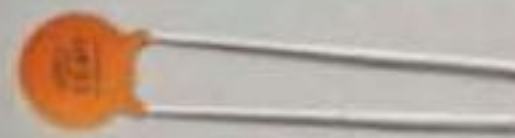
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- ☐ 10kohm resistor
- ☐ 4.7kohm resistor *
- ☐ .01uF ceramic capacitor *
- ☐ 1uF ceramic capacitor
- ☐ 10 uF electrolytic capacitor
- ☐ Momentary switch (SPST)
- ☐ Toggle switch (SPST) *
- ☐ 2 x control knob *
- ☐ 9v snap connector
- ☐ 9v battery *
- ☐ Panel-Mount Jack
- ☐ 500k-Ohm Volume Control with Push Switch

* Pictured Right →



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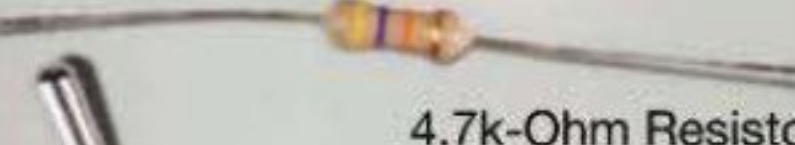
Hexagonal Control Knobs



1k-Ohm Resistor



4.7k-Ohm Resistor



Toggle Switch (SPST)



8-Ohm Mini Speaker



9V Battery



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SCAN THIS QR CODE TO LEARN MORE ABOUT THIS PROJECT



of combinations of these settings that will produce a correct exposure—but each alters the style of the photograph. Taking a picture manually is like going on a road trip from New York to San Francisco—you can take many routes. Full auto, though, is like a GPS unit that tells you to take I-80 every time. To plot a more creative course, you need to learn the basics of manual control.

Aperture



FOR **PORTRAITS**,
LANDSCAPES, CLOSEUPS,
LOW-LIGHT SHOTS

➔ **Set the mode dial to A** (or Av in Canon cameras). Depending on what model you own, you'll use either a dial or buttons to adjust the size of the aperture—the hole in the lens that controls the rate at which light passes through to the sensor. The size of the aperture is called the f-stop and shows up as a number displayed on top of the camera or on the rear screen.

Full auto favors middle-of-the-road apertures such as f/5.6, but you're going to want to play with the extremes. For landscape shots, like the one of Yosemite's Half Dome on the opening page, put your camera on a tripod and select a very small aperture (one with a high number), say, f/22. That maximizes depth of field so that everything from the trees in the foreground to the iconic cliff in the distance shows up in focus.

To draw attention to a particular part of the picture, though, choose a wide aperture (one with a low number), such as f/2.8 or below. In the robot photo (top right), I focused on the fingertip and shot at f/2 to minimize depth of field. Only its left hand is sharply in focus, creating the impression that this menacing machine is reaching out to touch you. Wide apertures are great for human portraits too.

Shutter Speed



FOR NIGHT SCENES,
ACTION SHOTS, **IMPLIED**
MOTION, SPORTS

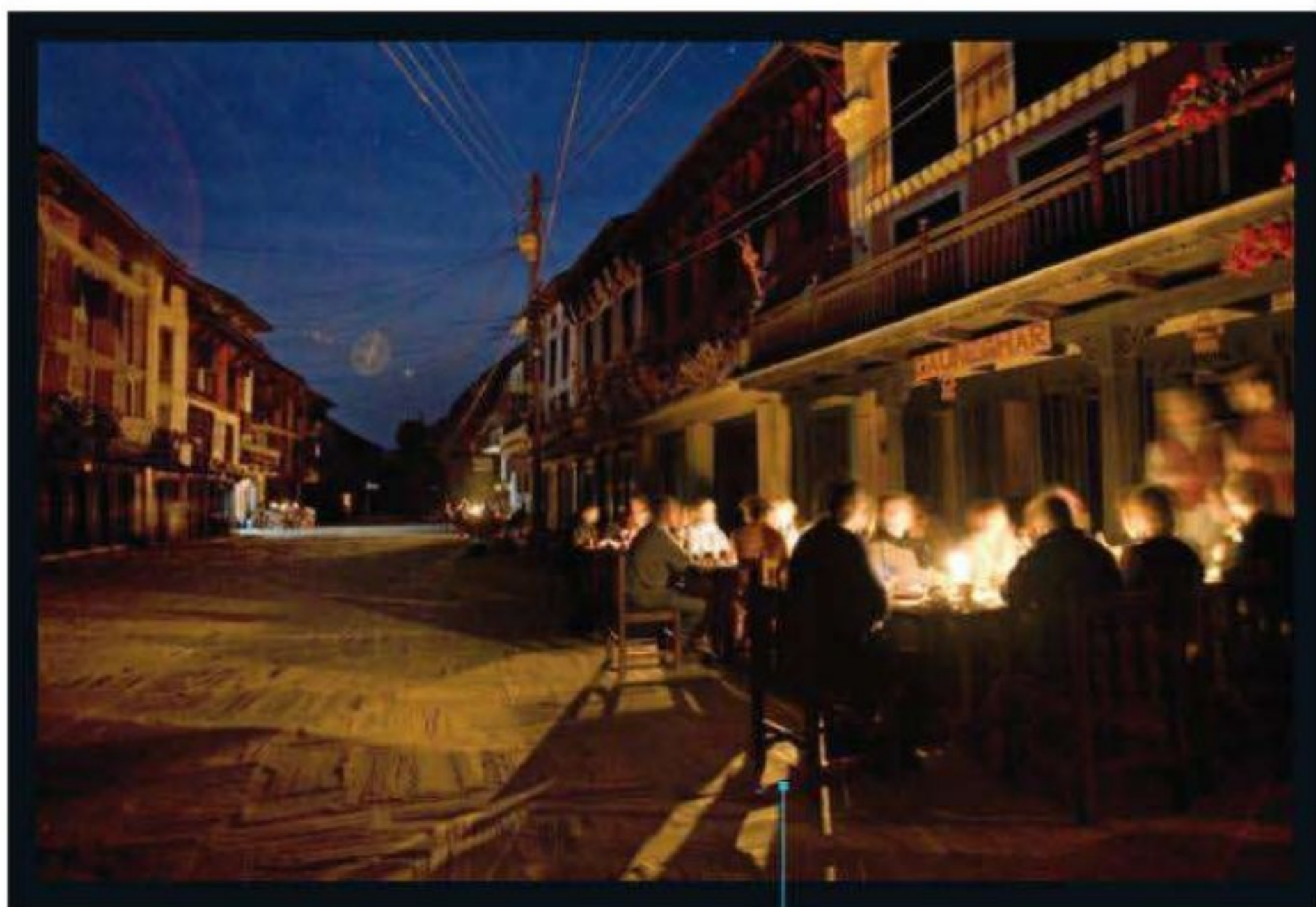
➔ **Shutter speed** determines how long the camera's aperture stays open



to admit light to the digital sensor, and full auto likes to play it safe on this front too. It generally opts for middling speeds from $\frac{1}{80}$ to $\frac{1}{500}$ of a second, which reliably produce blur-free images. But reliable can be boring.

When photographing things that move, turn the mode dial to S (or Tv in Canon cameras). In bright light, choose a very fast shutter speed, $\frac{1}{1000}$ or higher, to freeze action. You'll see every little drop of spray as a whitewater raft blasts through rapids, and each clod of dirt flying from the tires of a mountain bike.

Work the other end of the shutter-speed spectrum too. Slow shutter speeds ($\frac{1}{30}$ or longer) allow enough time for the moving person or object to blur, conveying motion. (Stabilize your camera, preferably on a tripod, so that only the moving subject comes out blurry.) Long exposures can also produce artistically interesting results in low-light situations. For the photo above of the person twirling fireballs, I used a 3-second exposure, enough time for a few full revolutions.



ISO

ISO FOR LOW LIGHT,
ACTION SHOTS, NIGHT SCENES,
FLASH-FREE SHOTS

➔ **This setting determines** how responsive the digital sensor is to light. At ISO 200, the sensor is twice as responsive to light as it is at ISO 100; ISO 400 is twice as light-sensitive as ISO 200, and so on.

The tradeoff is image noise: The higher the ISO setting, the more grainy, multicolored speckles pollute your pictures. Sensors have gotten much better at night vision, but noise often becomes noticeable beyond ISO 800.

Some cameras have a dedicated button to push when you want to change the ISO; others require you to use menus to make changes. For the picture of a café in Nepal (above left), I used ISO 800 and a 10-second exposure.

Flash Compensation

Flash Compensation FOR PARTY PICTURES,
OUTDOOR PORTRAITS,
LONG-RANGE FLASH

➔ **Full auto** sometimes goes gonzo on the flash, making your friends chatting in a bar look like wax statues at Madame Tussauds. For more tasteful results, start by selecting a wide aperture and higher ISO. These changes will allow your camera to capture more natural light, making it less reliant on the flash.

Next, manually set the flash to fire by pressing the lightning-bolt button found on many cameras or by raising the built-in flash module. Find your camera's flash-compensation button or menu item, symbolized by a small lightning bolt with a +/- symbol next to it. You'll see a numbered scale. Try setting the flash for -1.3, then -0.7, and so on, until the lighting is appropriately subdued.

The photo of the hiker (above, top right) shows another way to use this feature. With the subject in front of you, aim at the sun. Find the exposure-compensation control (not the one for the flash), which on most cameras is a button with a +/- symbol on it. Change it to around -1. This helps you get a blue sky and keeps the sun from being too bright. Then dial the flash compensation to +1. The result will be an into-the-sun shot with both the subject and bright background properly exposed.



Spot Meter

Spot Meter FOR COMPLEX LIGHTING,
OUTDOOR PORTRAITS,
LANDSCAPES, SILHOUETTES

➔ **The shot of the Andes** (above, bottom right) presented a classic light-metering challenge—a scene containing both bright and dark elements. In high-contrast scenarios, full auto splits the difference to capture as much of the highlight and shadow detail as possible. The resulting shot is often an unsatisfying compromise.

For better results in high-contrast scenes, set the camera to the spot-metering mode, symbolized on the display screen by a dot inside a box. Then decide what's most important visually. Center the area of interest in the viewfinder—in my photo, the sky and mountains—and depress the shutter button halfway. This tells the camera, "Give me a perfect exposure of what we're looking at right now." With the shutter still half-depressed, you can adjust the composition, then push further to shoot.

This technique left the mountaineer and foreground slopes underexposed to the point of becoming silhouettes, but that added visual punch. Compromise is overrated. So take the next exit from full-auto I-80 and have a little more fun.

PM

Digital Clinic

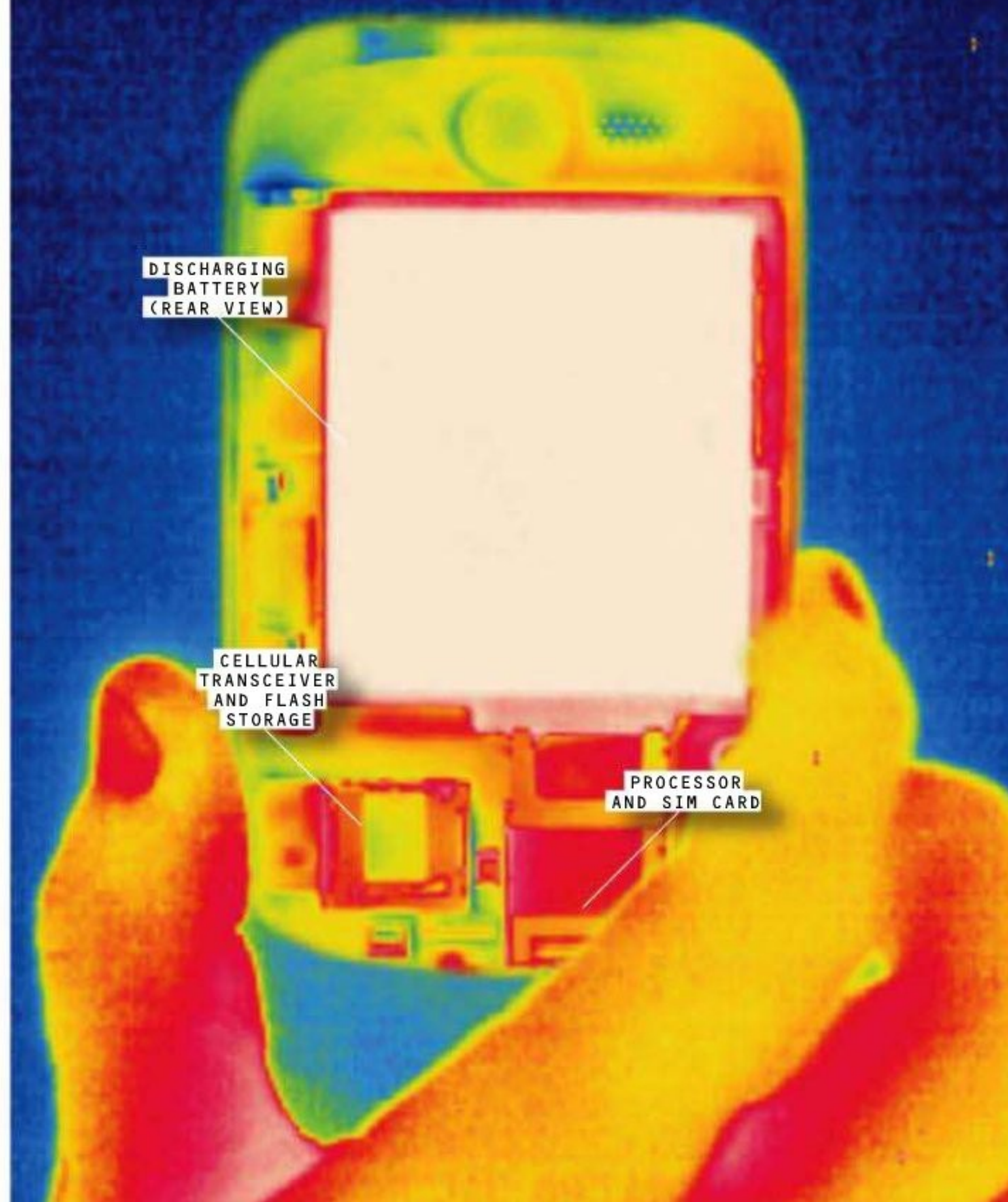
by John Herrman

Q+A

Q

Hot Pockets

My smartphone gets hot. Not so hot that it burns my hand, but close. Is something wrong?



A A little heat from an electronic device is normal. It's an unavoidable side effect of charging, discharging, processing and illuminating. Stick your hand behind the ventilation grille of an HDTV or a cable box, or feel the bottom of your laptop. These things are like space heaters.

Just because gadget heat is normal doesn't mean it's good. To a user, excessive warmth emanating from a device may be irritating or even alarming; to the gadget—in particular, its battery—heat is a mortal threat. "Heat is a killer of all batteries," says Isidor Buchmann, CEO of battery-testing firm Cadex Electronics.

He's not exaggerating: According to his research, a lithium-ion battery stored at 40 percent charge and 104 degrees Fahrenheit—a realistic temperature for common cellphone use—will lose 15 percent of its capacity over the course of a year. That number jumps to 35 percent if the battery is stored at full charge, as in the case of a laptop that's left plugged in all day.

So, what, if anything, can be done about an overheating gadget? There are three common causes of a feverish phone: poor signal, intense workload and battery charging. There isn't much you can do about a poor signal. Smartphone operating systems are fairly good at keeping renegade software in line, but it's worth checking to see if there are any apps running in the background. The most likely culprit is actually a phone's case—especially if it includes a battery pack of its own. Let your phone go nude for a day, and see if that helps.

A scalding laptop can usually be explained by either an overactive processor or poor ventilation. Press CTRL+ALT+DELETE on a PC or open the Activity Monitor app on a Mac to check if any programs are straining the processor, then close or uninstall the worst offenders. Propping up a hot laptop to improve airflow will go a long way too:

Processors, transceivers and graphics units can be major sources of heat in smartphones. But it's probably the battery that you're feeling through your pant leg.

PHOTOGRAPH BY DEVON JARVIS

Some laptops, such as Apple's, use their entire bodies as heat sinks.

Lastly, take a peek inside your computer's exhaust or intake ducts. A dust buildup can result in severe overheating. If you're willing, you can partially disassemble your computer and clean with compressed air or a fine brush.

If a gadget's temperature gets out of hand, the device will usually attempt to save itself. A laptop will simply shut off without warning; smartphones will display a visual warning, then power down. If the problem persists, contact the manufacturer—persistent or extreme heat could be a sign of thermal runaway, which can result in a burst battery.

Business Expenses ➔ I need to access my work email from my personal phone, but my carrier insists that I need to pay an extra \$15 for a business plan. Is this necessary?

Probably not. Unless you're a BlackBerry user, these Enterprise or Pro data plans are not required to access Exchange email or corporate computer networks (virtual private networks, or VPNs).

Android, iOS, Windows Phone and webOS smartphones include software to connect to corporate accounts and can be synced to Exchange servers for email, calendars and contacts using any smartphone data plan. That's because the connection itself is identical to that of a consumer plan: Data travel over the same network, pass through the same back-end hardware and use the same network protocols.

Customer service will often attempt to upsell customers to a corporate data plan whether or not it will be subsidized by their employer—in either case, they will very likely be wasting \$15 a month. In a call to AT&T customer service, I was told repeatedly and without elaboration that the corporate data plan "is the only plan that allows business use." Both Exchange email and a Cisco corporate VPN, however, work on my iPhone with a cheaper, consumer-oriented plan.

Nonetheless, some employers may require a pro-level data plan. Ask your HR rep, or, better yet, buy your office IT guy a beer.



FRAUD ALERT

FIGHTING ILLEGAL PHONE CHARGES

THE FCC HAS ANNOUNCED A RENEWED CRACKDOWN ON A PRACTICE KNOWN AS CRAMMING, IN WHICH COMPANIES CHARGE PHONE USERS FOR SERVICES WITHOUT THEIR CONSENT. THE FIRST AND STRONGEST LINE OF DEFENSE, HOWEVER, IS YOU. HERE'S HOW TO SPOT—AND THWART—PHONE-BILL CRAMMING. BY JOHN HERRMAN

Services

1	911 Service Fee	\$1.09
2	Regulatory Cost Recovery Charge	\$0.49
3	Federal Universal Service Charge	\$1.74
4	Telecommunication Surcharge	\$0.38
5	State Excise	\$1.57
Total		\$5.27

Misc Charges and Credits

6	Line Fee, ABC Teleservices, 1-800-555-8495	\$9.99
7	Membership, ACME Payments, 1-800-555-4321	\$1.99
8	Line Protection, FraudCo, 1-800-555-6132	\$4.99
9	State Tax	\$1.36
Total		\$18.33

➔ Read your bill

The only way to spot cramming is to keep an eye on your bill. Look for vague names: "Service Charge," "Line Fee," etc. If you don't recall asking for it, it shouldn't be there.

➔ Research the company

Have you ever done business with these people? Can you even tell what they do? Often, crammers will bill through a generic payment-processing firm.

➔ Demand a refund

First, call the company that levied the charge. If they offer resistance, make note of their claims and appeal to your phone company. Don't back down.

➔ **Take it to the top** These charges may be small, but they add up over time. If all else fails, notify the authorities: Both the FCC and FTC will take cramming complaints online at fcc.gov and ftc.gov, respectively.

The Accidental Pirate ➔ My family and I don't illegally download movies or music (as far as I know, at least). We do, however, use a ton of bandwidth—Netflix, gaming, music streaming, etc. I read that Internet service providers are cracking down on downloaders and pirates. Does that change anything for us?

Unless your kids are sneakily downloading movies on BitTorrent, then, no, the new Copyright Alert antipiracy system shouldn't affect you. The standardized warning system, designed by ISPs and the Center for Copyright Information—a coalition of film, music and TV companies—is targeted at people who actively share content illegally.

The new system works like this: A content owner notifies an ISP that one of its users is hosting illegal material on BitTorrent or a similar service; the ISP warns said pirate that he's been caught; if the pirate doesn't cease and desist, the ISP throttles his connection to 56K modem speeds until he does. **PM**

Got a technology problem?

Ask John about it. Send your questions to pmdigitalclinic@hearst.com. While we cannot answer questions individually, problems of general interest will be discussed in the column.



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HAND IN YARDWORK.
BY ROY BERENDSOHN

They're called leaf blowers, but they do more than move leaves. They sweep a patio clean of grass clippings or blast a winter's worth of sand off the driveway. They can also annoy your neighbor as you stand there in a trance blowing a few spoonfuls of dust. Used responsibly, these tools are as efficient a timesaver as a power lawnmower, and new designs have better grips for two-hand control. So we tested eight two-stroke leaf blowers by moving all kinds of debris. We learned that their rating for airspeed and volume is an unreliable gauge of effectiveness—some of the least air-worthy were the most trustworthy. Here are our findings.

INSIDE



KITCHEN-FIX-UP TIPS + USING CASTOFF PARTS + SEALING DRIVEWAYS

PHOTOGRAPHS BY SCOTT JONES

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DIY

Home LEAF-BLOWER TEST

Rating



CRAFTSMAN
358.794774

ENGINE SIZE: 25 cc
DECIBELS (A-WEIGHTED): 95
AIRSPEED/VOLUME:
215 mph/470 cfm*
WEIGHT: 11.1 pounds
PRICE: \$145

Likes: The Craftsman is one easy-starting blower. Set its automatic choke to Start, give its recoil handle one or two gentle pulls, and the engine roars to life. The choke lever moves automatically to the Run position. The blower has good vibration isolation and comfortable handles. It moves debris well, if not exceptionally. **Dislikes:** The Craftsman is too heavy, and given its high air-movement numbers, it should blow leaves more effectively. Its locking nozzle is difficult to install and remove, requiring you to twist it on with a pair of large tongue-and-groove pliers.



ECHO
PB-250

ENGINE SIZE: 25.4 cc
DECIBELS (A-WEIGHTED): 92
AIRSPEED/VOLUME:
135 mph/390 cfm
WEIGHT: 9.5 pounds
PRICE: \$160

Likes: The Echo was one example of how misleading air-movement numbers can be. It has low numbers, but it's highly productive. To us, that indicates that an airstream has to be more than fast or have high volume—it has to be shaped for maximum impact. We liked the Echo's long tube, which lets you direct its tip close to what you need to move. Also, the tube's S-shaped curve helps reduce the blower's tendency to twist, reducing user fatigue. **Dislikes:** We don't like the tool's sliding Stop switch or its upside-down purge bulb, which is awkward to pump.



HITACHI
RB24EAP

ENGINE SIZE: 23.9 cc
DECIBELS (A-WEIGHTED): 95
AIRSPEED/VOLUME:
170 mph/441 cfm
WEIGHT: 9 pounds
PRICE: \$150

Likes: We're well-acquainted with Hitachi's electric power tools, and we're becoming more familiar with its gas-engine products. We like what we're seeing. This little green blower is lightweight and produces an effective airstream. We found it worked well moving soggy leaves and prickly seedpods. **Dislikes:** The air-cleaner element is a skimpy little ring of die-cut foam that doesn't look like it provides enough protection for the engine. The blower nozzle is too short, reducing the effectiveness of its airstream. The nozzle needs to be able to get in close to debris.



HUSQVARNA
125B E-TECH

ENGINE SIZE: 28 cc
DECIBELS (A-WEIGHTED): 94
AIRSPEED/VOLUME:
130 mph/425 cfm
WEIGHT: 9.4 pounds
PRICE: \$150

Likes: The Husqvarna was another example of how air-movement numbers can be misleading. Its air numbers are low; its ability to do the job is high. We attribute that to a well-focused airstream that doesn't waste its energy on turbulence—in the blower tube, in the housing or at the impeller. Wisely, Husqvarna also provides a fan-shaped nozzle (not shown) that increases the blower's ability to skim refuse from pavement. Finally, the tool's light weight and good balance make it easy to handle. **Dislikes:** Nothing noted.

* Volume in cubic feet (of air) per minute; Craftsman and Poulan Pro airspeed measured with narrow-nozzle accessory, not shown. Volume reading taken in vac mode.



●●●●●
POULAN PRO
 BVM210VS

ENGINE SIZE: 25 cc
DECIBELS (A-WEIGHTED): 92
AIR SPEED/VOLUME:
 210 mph/460 cfm
WEIGHT: 10.75 pounds
PRICE: \$135

Likes: The Poulan and its performance are essentially identical to the Craftsman's. It starts with a slow and gentle pull of its recoil handle, and its automatic choke lever sets itself to the Run position after the machine starts, which it always does with one or two pulls. It's a good leaf mover, even if it isn't the best, and it moves all other types of yard debris effectively.
Dislikes: Like the Craftsman, the Poulan is heavy compared with other blowers, and its nozzle twists on only after a considerable effort. The Poulan's high air numbers weren't reflected in its leaf movement.

●●●●●
STIHL
 BG 55C

ENGINE SIZE: 27.2 cc
DECIBELS (A-WEIGHTED): 95
AIR SPEED/VOLUME:
 143 mph/418 cfm
WEIGHT: 9.1 pounds
PRICE: \$150

Likes: The Stihl's air-movement numbers were low compared with other blowers, but we found it moved debris better than those with higher numbers—the airstream is optimized, focused and less turbulent. We suspect that somebody looked carefully at the impeller, the blower-tube length and the tube's taper and diameter to make the most of the air it moves. The tool's light weight further improves its productivity.
Dislikes: Our one small gripe is that the Stihl needs a momentary Stop switch, not one with a fixed position.

●●●●●
TANAKA
 TRB 24EAP

ENGINE SIZE: 23.9 cc
DECIBELS (A-WEIGHTED): 95
AIR SPEED/VOLUME:
 170 mph/441 cfm
WEIGHT: 9 pounds
PRICE: \$150

Likes: Except for the orange color and its distribution through power equipment dealers (not, for example, Lowe's), the Tanaka is the same as the better-known but equally aggressive Hitachi. It's a highly energetic, lightweight yard tool, especially when it comes to moving damp material.
Dislikes: Just like the Hitachi, this tool needs a longer nozzle to put its airstream closer to the ground and what you want to move. It also needs a more substantial air filter, not the skimpy die-cut foam one it's equipped with. A better filter will likely improve performance and extend engine life.

●●●●●
TROY-BILT
 TB2BV EC

ENGINE SIZE: 27 cc
DECIBELS (A-WEIGHTED): 95
AIR SPEED/VOLUME:
 150 mph/500 cfm
WEIGHT: 9.85 pounds
PRICE: \$150

Likes: We appreciated the fact that the Troy-Bilt was designed for folks who want to use a leaf blower with two hands. Sure, you can operate it with one hand, but it has two handles below its body, and the weight distribution and ergonomics are clearly designed for two hands, unlike other machines. These features permit better maneuverability when you pivot the blower to the side or vertically. If not an exceptional leaf mover, it's certainly a good one, and it starts with an easy pull of the recoil handle.
Dislikes: The blower is a little too heavy, and its die-cut foam air filter is a bit on the scrawny side.

Homeowners Clinic

by Roy Berendsohn

Q+A



The Forest in the Kitchen

My wife and I are remodeling our kitchen, and I'm considering using some beautiful reclaimed pine from a local dealer as shelving or trim. Can you give me some tips about working with salvaged wood? My wife is counting on me to do a nice job, and this is my first real woodworking project. Any thoughts on fixing up a kitchen on a tight budget are also welcome.

A Okay, got it. First I'll address working with reclaimed lumber; then I'll turn to budget kitchen fix-ups.

Reclaimed lumber, especially pine, can be a wonderful material. Barns, boardwalks, houses and warehouses, barracks, factories, bridges, and water tanks and towers are sometimes called the industrial forest. Wood from these structures is extremely high-quality because it comes from beautiful old trees that grew very slowly to a large diameter. The slow growth produces a dense grain pattern because the more slowly a tree grows, the narrower its characteristic bands of light- and dark-colored wood (early and late wood, respectively).

But using reclaimed pine for the purposes you describe can present challenges. It can have small cracks, holes and rust stains left from nails and screws; buried hard-



Reclaimed lumber from a railroad trestle made attractive shelves in this small kitchen.

ware or hardware fragments; insect boreholes; and wear marks from decades of use.

For many, character is part of the charm of reclaimed lumber. But if that's not to your taste, you'll have to buy a planer, a table saw and maybe even a jointer and convert the lumber into more uniform, blemish-free stock. Of course, removing these details misses the point and creates a ton of waste.

Regardless of whether you use the lumber as you find it or remanufacture it, consider buying a metal detector (\$50 to \$170) to find any hardware that

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may be buried in the wood. But you'll likely miss some metal even after using it—don't be surprised if you end up buying extra blades and bits to replace those damaged by stray hardware.

I hope I don't sound like I'm discouraging you from using reclaimed wood. It just requires a bit more care than new lumber. Speaking of which, the less finish you apply, the better. A thin layer of shellac or penetrating oil is all you need to bring out the lovely, dense grain.

Now, on to inexpensive fix-ups. Obviously, you get the most mileage from paint (\$120 is probably enough to cover your walls, ceiling and any non-reclaimed woodwork that needs paint). Other inexpensive touches that can make a dramatic difference are new covers for switches and electrical outlets (about \$100 to \$200 total), and cabinet knobs or pulls (\$100 to \$150 total). And even though you can't see it, a trash-can slide is always worth adding (\$30 to \$50). New blinds go a long way toward improving a kitchen's appearance (\$70 to \$100). In fact, I'd consider making a window valance from some of the reclaimed wood. It could be the crowning touch.

After all the painting is done and the hardware replaced, I think your wife will be pleased—and so will you.

Flipping the Lid ➔ It's high time we had our septic tank pumped. The problem is that the company that does the work says we could save a considerable amount of money if we locate the lid rather than hire them to do it. What's the quickest way to find the lid?

Unfortunately, there's no foolproof answer here. Typically, you begin the search inside the house, not outside. Look for the point where the building's main drain exits the foundation. In most cases, the drain runs perpendicular to the foundation for about 10 feet and meets up with the septic tank. In some parts of the country, that distance can be as little as 6 or 7 feet. Ask your pumping company for advice on that matter.

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DON'T THROW IT OUT

THE FIX FOR STRIPPED HOLES

WHAT TO
KEEP
→

Braided copper ground wire clipped from old light fixtures; electrical screws of various sizes.

WHY YOU
KEEP 'EM
→

It's not unusual when you change a light fixture mounted to a plastic box to have the holes for the mounting screws strip out.

HOW TO
USE 'EM
→

Slip a piece of the braided copper ground wire into the stripped hole and clip off excess wire so that none protrudes. Drive the mounting screw as you normally would. You can also use an electrical screw that's one size larger. Carefully drill out the stripped hole and drive the bigger screw. In some cases, you can skip the drilling and just drive the screw.



You can also check with the town or the county. Your municipality may require that the position of the tank and the rest of the house's waste system be indicated on a plot plan or a similar document.

If you have the plans, use a tape measure to locate where the tank is. Probe with a shovel or use a digging bar with a sharp tip. The top of the septic tank will be anywhere from 4 inches to 1 foot belowground. When digging a test hole, remember to remove a square patch of sod so that it can be easily put back into place after the tank is pumped or when you go to make another test hole.

Sometimes a tank lid is easy to find and requires no more than half an hour to an hour of careful probing and digging; other times it can take a couple of hours. It makes you appreciate why some pumping companies now use flushable transmitters. The pumping contractor flushes a transmitter down a toilet and then finds it by sweeping over the ground with a locator. Other companies use a metal detector to seek out the piece of bent rebar that is sometimes cast into a tank's concrete lid. In any case, you're making a smart move by locating the tank yourself.

The Seal Deal ☹️ I'm going to seal my asphalt driveway this fall. I've never done this before, and I don't want to make a mess out of it. I would appreciate any advice you can give me about what kind of sealer to use and the best way to do this work.

Sealing a driveway is about as simple as DIY projects go, and freshly sealed asphalt can make a world of difference to a home's attractiveness, not to mention greatly increase the pavement's durability.

Begin by cleaning the driveway with a stiff-bristle broom or a leaf blower. Scrape clean any cracks that are filled with weeds (use an old reciprocating-saw blade for this). Patch and firmly compact potholes with cold-patch asphalt, and seal cracks with crack filler. To repair large cracks, either pack the bottom with sand or lay in a length of foam backer

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rod before applying crack sealer. Next, apply oil-spot primer to greasy spots with an old paintbrush. This prevents the spot from bleeding through the seal coat.

Finally, use masking tape, paper and sheet plastic to protect adjoining surfaces, such as sidewalks, foundation walls, garage doors or floors, or retaining walls. Sealer that gets splashed accidentally on these surfaces is nearly impossible to remove.

You've got several choices of driveway sealer. Coal-tar sealant is the traditional product; its primary component is the refined tar formed when bituminous coal is converted to coke, a steel-making fuel. Coal-tar sealer is still the go-to material of the pavement-sealant industry; it's favored because it resists degradation from the sun's UV rays and doesn't dissolve easily when blemished by motor oil and automotive chemicals. Coal tar, however, is at the center of an ongoing controversy. In 2006, Austin, Texas, banned asphalt sealers that contain the material, citing a study that found polycyclic aromatic hydrocarbons (PAHs) had accumulated in waterways. An industry trade group, the Pavement Coatings Technology Council, fired back with counter-studies that took that research to task for flawed methodology, and noted that PAHs are also found in auto exhaust and the residue from burning wood and charcoal, among other sources.

Where does that leave you? Coal-tar sealants are still available almost everywhere in the country, but if the possible environmental risk concerns you, then your best choice is to use a sealer formulated from asphalt emulsions (which contain a tiny fraction of the PAHs found in coal-tar formulations). There are also sealers made from acrylic emulsions. Although I haven't seen data on PAHs in acrylics, I would estimate that their level is at least as low as in asphalt emulsions and probably lower. Expect to pay \$3 to \$4 a gallon for asphalt-emulsion blends, and \$12 a gallon for acrylic sealers.

Regardless of the sealer you use, reduce chemical-containing runoff from

the driveway by applying the sealer when the forecast is for dry weather. The longer the post-application stretch of dry weather, the better. The sealer should have a chance to cure before it rains.

Test Pilot ☞ **My detached garage is heated with a ceiling-hung gas furnace, and the pilot flame often blows out when I open the garage door. Obviously, this is a nuisance. What's the solution? I can't always bring in tools, equipment and materials through the side door.**

First, have a heating contractor inspect the furnace. Yes, a pilot flame can easily be blown out by high wind, but it's also possible that the pilot flame is weak or that the furnace needs a tuneup. A weak pilot flame can be caused by gas pressure that's too high or too low, a dirty pilot-light orifice or just ordinary wear and tear—to name a few of the many causes. A quick visual check can confirm whether the flame has a light blue color and a correct shape, which can range from that of a bullet to the form of a butterfly wing seen from above.

Ruling out a weak pilot, you might ask your heating and cooling contractor to install an aftermarket automatic relighter, such as the one made by Adams Manufacturing. This device produces a stream of ignition sparks until the pilot relights itself or the thermocouple cools to the point that the gas-control valve closes, shutting off gas flow to the appliance.

Tool Lurker ☞ **I'm a longtime reader and online lurker of all things PM. I'm beginning to take on new home projects, so I'm requesting more tools for special occasions like my birthday. I point family members to your website and ask for the tools that you recommend. But that means I've got many different brands of power tools. Is there one brand that ranks best overall? This would be particularly helpful to know concerning cordless power tools, so that I can swap batteries as much as possible.**

We get asked this question a lot. The simple answer is no. Over the past 20 or so years, we've found that each manufacturer has at least one strong suit. For example, we haven't seen a reciprocating saw yet that can outcut the iconic Milwaukee Super Sawzall, and Bosch's jigsaw handily beat all comers in a recent test. Among cordless tools, we've had consistently high results from Bosch, Makita and Milwaukee, to name three professional brands. DeWalt, Ridgid and other well-known names in the industry also perform very well in our tests, and some less expensive brands such as Hitachi, Ryobi and those sold by Harbor Freight provide more than enough performance for homeowner needs.

Even within brands, you might be attracted to smaller, low-voltage tools that take a stick-type battery that fits in the handle, while larger tools of the same marque use a larger, slide-on type of battery. If you find yourself needing to swap batteries among various tools, buy a combo kit, such as one that contains a drill, a circular saw and a reciprocating saw.

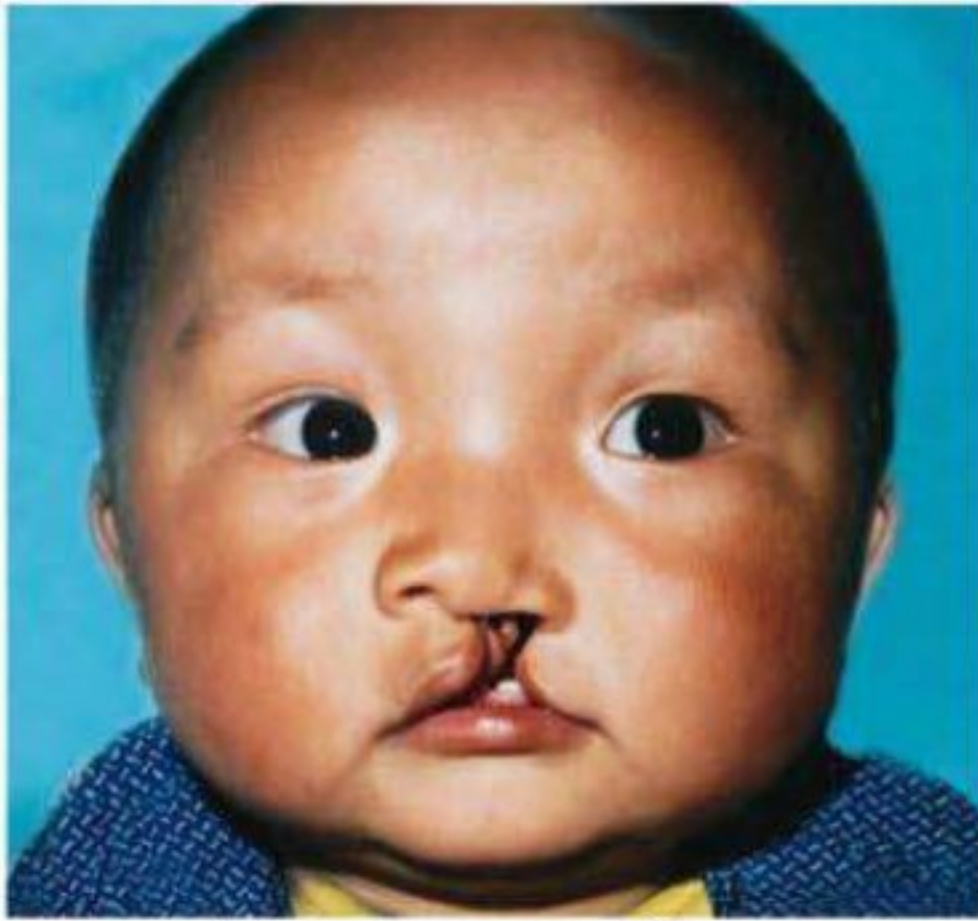
I suppose I'm just stating the obvious, but sooner or later manufacturers should settle on a standard battery configuration. Yes, we've heard a lot of reasons from manufacturers over the years about why this isn't possible. But then again, other industries have put this kind of squabbling behind them and moved on to successful standardization. It's time for the power tool industry to do this too. **PM**



Got a home-maintenance or repair problem? Ask Roy about it. Send your questions to pmhomeclinic@hearst.com or to Homeowners Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.

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Ming, 6 months, China



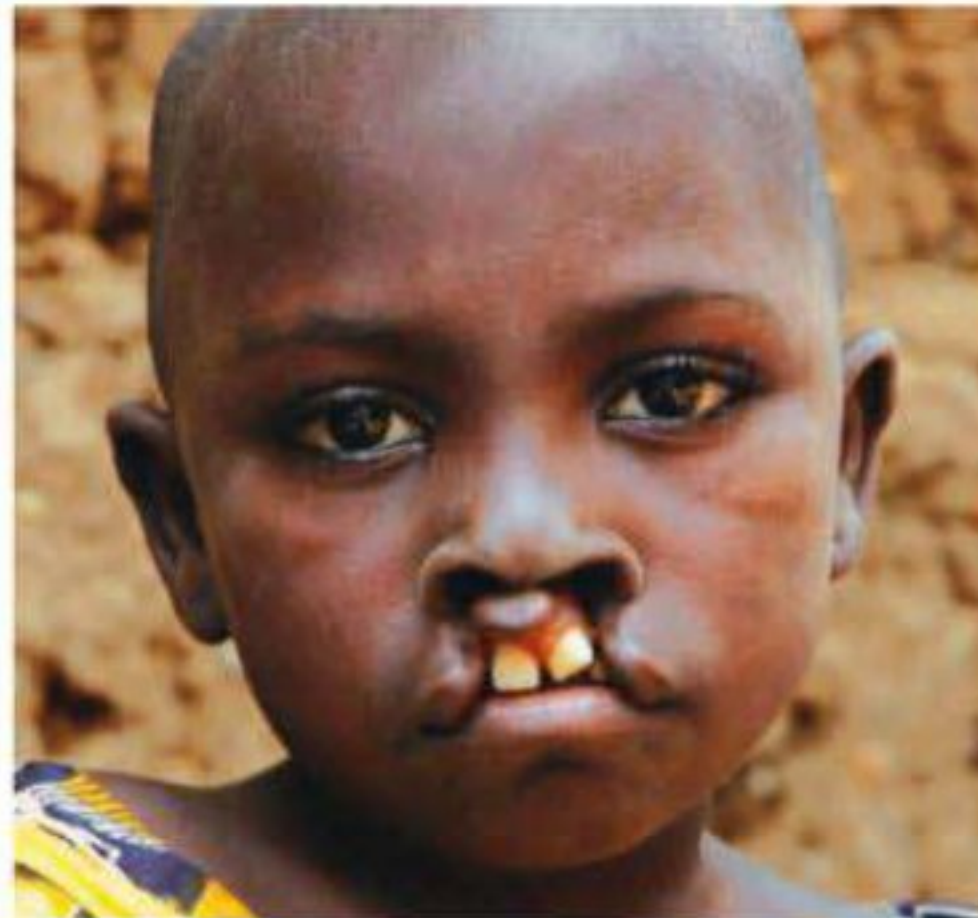
Shiva, 1 year, India



Mot, 13 years, Cambodia



Durgap, 5 years, India



Funmi, 8 years, Nigeria



Salazar, 5 years, Philippines

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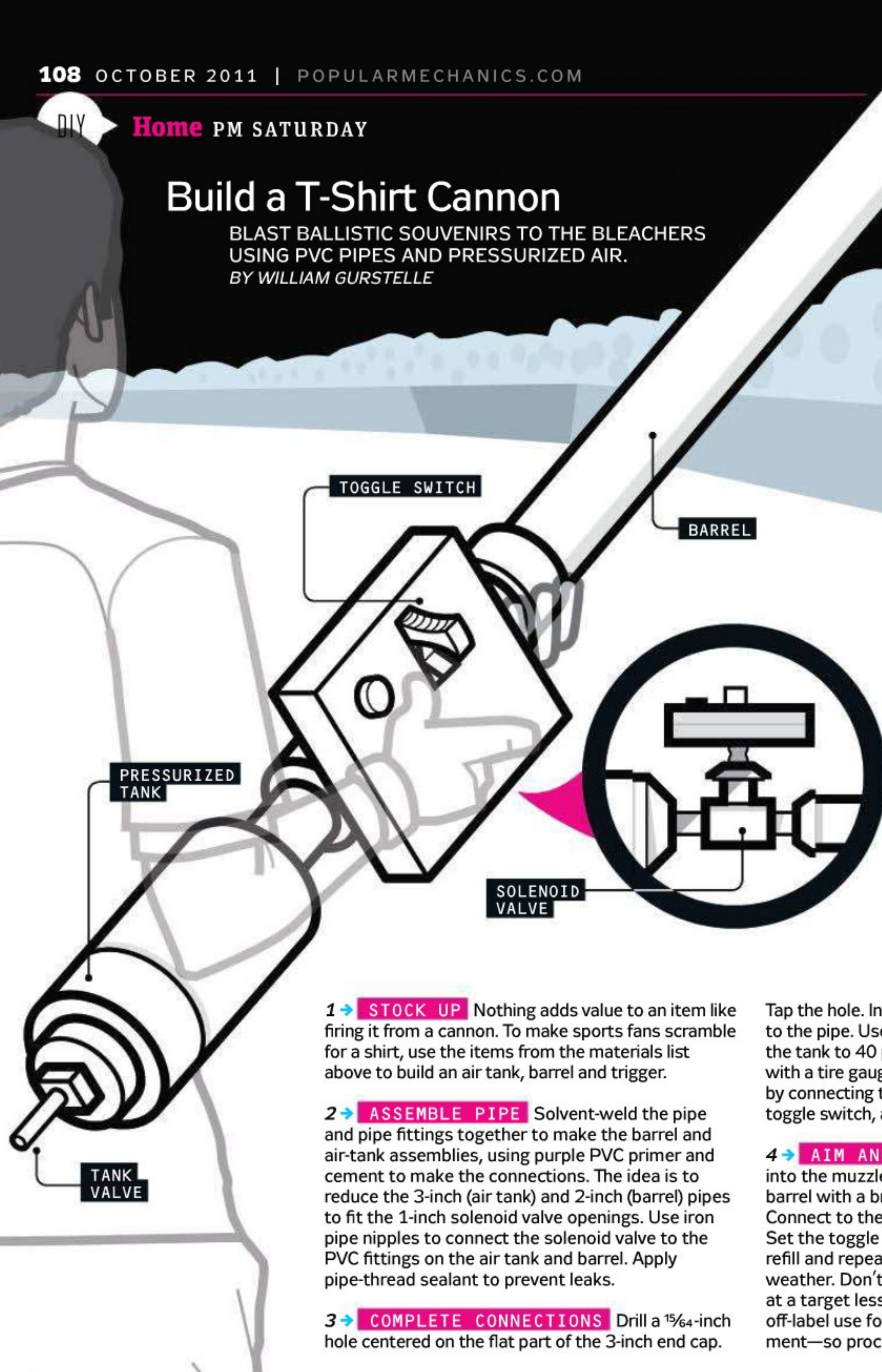
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DIY

Home PM SATURDAY

Build a T-Shirt Cannon

BLAST BALLISTIC SOUVENIRS TO THE BLEACHERS
USING PVC PIPES AND PRESSURIZED AIR.
BY WILLIAM GURSTELLE



MATERIALS LIST

- 1 36-inch length of 2-inch-diameter PVC pipe
- 1 16-inch length of 3-inch-diameter PVC pipe
- 1 3-inch threaded-to-smooth PVC coupling
- 1 3-inch threaded end cap
- 1 3-to-2-inch PVC reducer fitting
- 1 2-to-1-inch PVC reducer bushing
- 1 2-to-1-inch PVC reducer fitting
- 2 1-inch-diameter iron pipe close nipples
- 2 1-inch smooth-to-NPT PVC adapter fittings
- 1 1-inch-diameter 24-volt sprinkler solenoid valve
- 1 Momentary pushbutton switch
- 1 On/off toggle switch
- 3 9-volt batteries and harnesses
- 1 Electronic project box
- 1 Pipe-thread sealant
- 1 1/4-inch NPT tank valve
- 1 Mötley Crüe T-shirt

1 → STOCK UP Nothing adds value to an item like firing it from a cannon. To make sports fans scramble for a shirt, use the items from the materials list above to build an air tank, barrel and trigger.

2 → ASSEMBLE PIPE Solvent-weld the pipe and pipe fittings together to make the barrel and air-tank assemblies, using purple PVC primer and cement to make the connections. The idea is to reduce the 3-inch (air tank) and 2-inch (barrel) pipes to fit the 1-inch solenoid valve openings. Use iron pipe nipples to connect the solenoid valve to the PVC fittings on the air tank and barrel. Apply pipe-thread sealant to prevent leaks.

3 → COMPLETE CONNECTIONS Drill a 15/64-inch hole centered on the flat part of the 3-inch end cap.

Tap the hole. Insert the tank valve and screw the cap to the pipe. Use a compressor or foot pump to fill the tank to 40 psi. Check pressure and test for leaks with a tire gauge. Build a circuit to control the launch by connecting three 9-volt batteries in series with a toggle switch, a pushbutton trigger and the solenoid.

4 → AIM AND FIRE Tightly roll a T-shirt, slip it into the muzzle and push it to the bottom of the barrel with a broomstick. Put on safety glasses. Connect to the air tank and pressurize to 40 psi. Set the toggle switch to on. Aim and fire. Reload, refill and repeat. Warnings: PVC weakens in cold weather. Don't overpressurize the tank. Don't fire at a target less than 30 feet away. This is an off-label use for PVC and water sprinkler equipment—so proceed at your own risk.

+ MORE TO DO IN OCTOBER

Forge Ahead

→ "Our mission in life is to get people smithing," Houston Area Blacksmith's Association treasurer Ed Malmgren says of Forge Fest. Hone your anvil skills Sept. 30 to Oct. 2 in Oldenburg, Texas.

Thwart Vermin

→ Critters come in as weather cools, Bruce Hunt, of United Wildlife Control, says. Inspect potential home entry points—chimneys, soffits, siding—and "make sure everything is sealed tight."

Fly a Killer Kite

→ See cutthroat sport-kite action at the 25th annual Outer Banks Stunt Kite Competition Oct. 8 to 9 in Kill Devil Hills, N.C. Kids attend kite-building workshops, and pros take in stunt demos between battles.

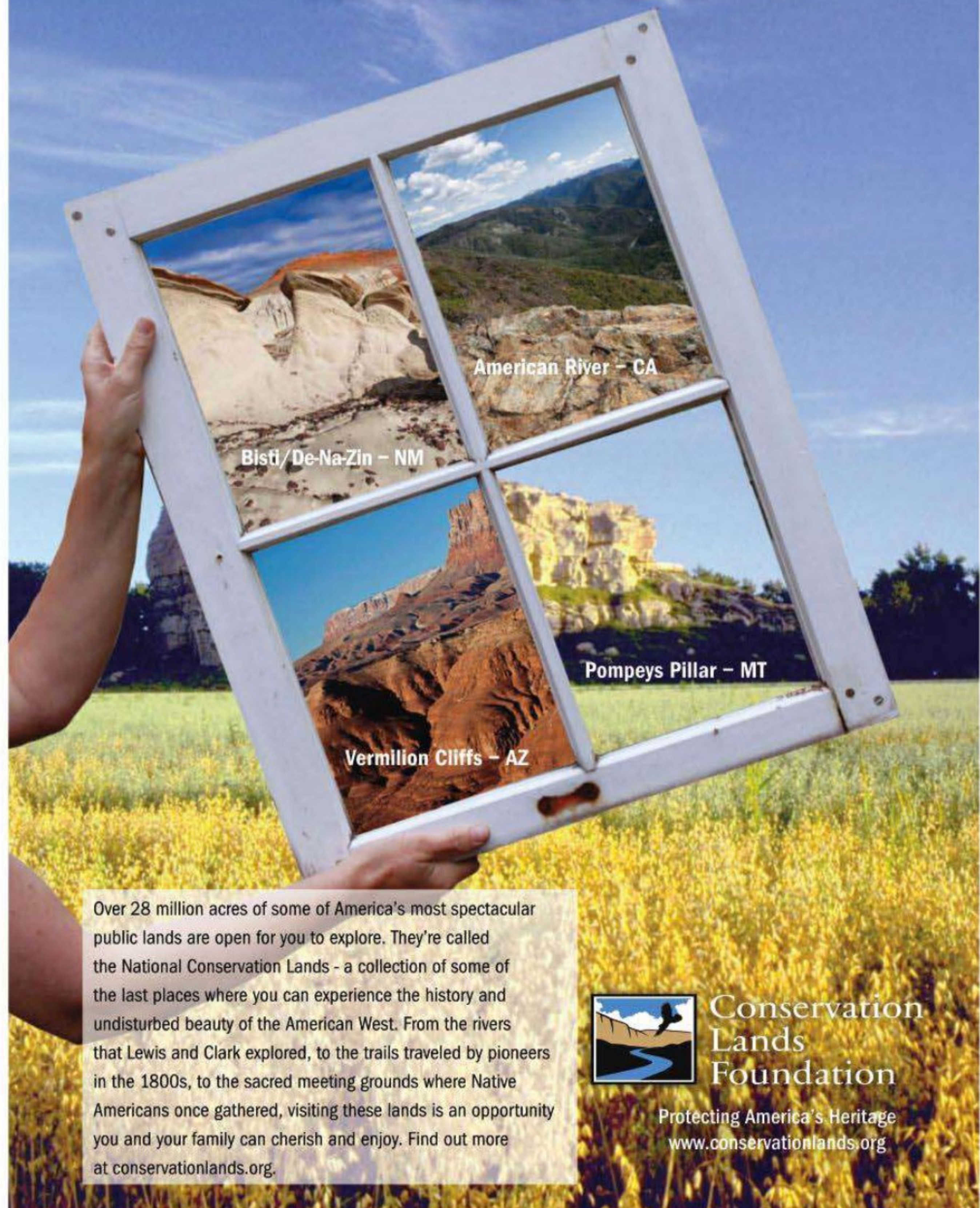
Gouge a Gourd

→ Pumpkin-carving Picasso Jay Ball alters X-Acto knives to sculpt elaborate jack-o'-lanterns in Smithfield, Utah. "Put a coping saw blade in the X-Acto handle," Ball says. "Usually a finer tooth size is better."

Saw Lakeside Logs

→ Spend Oct. 5 to 14 in Isabella, Minn., with Ron Brodigan of the Great Lakes School of Log Building to learn the full-scribed style. "No prerequisites," Brodigan says. "Just the dream of building with logs."

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Bisti/De-Na-Zin - NM

American River - CA

Vermilion Cliffs - AZ

Pompeys Pillar - MT

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DIY

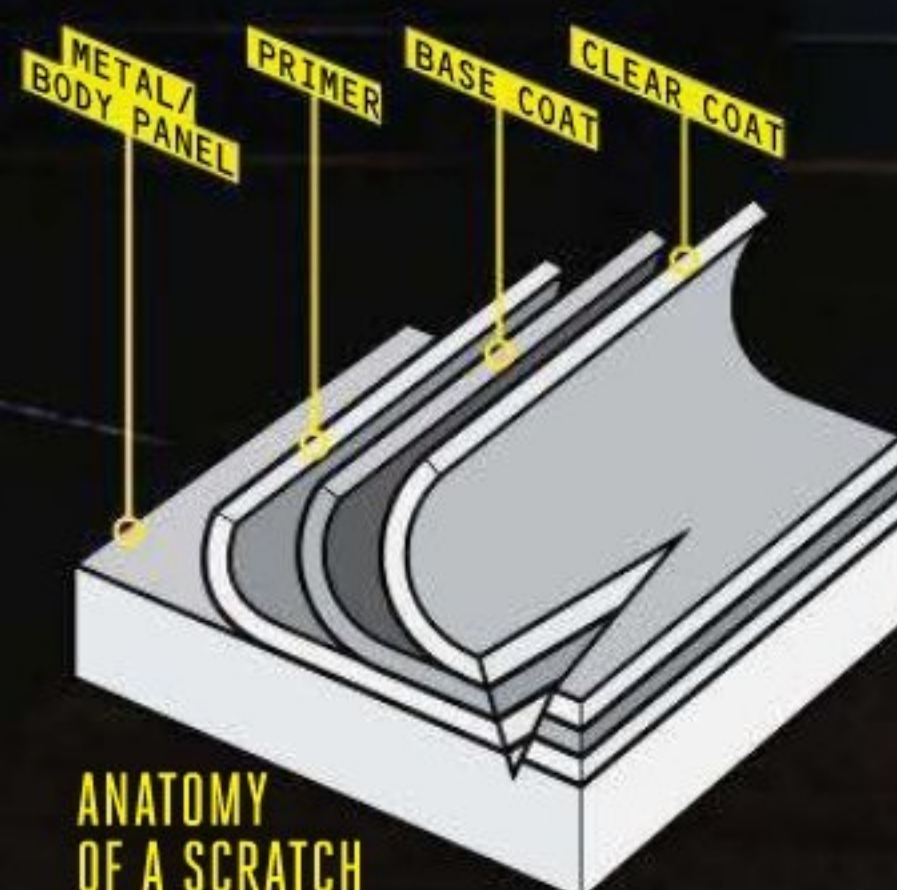
AutoSaturday
Mechanic

degree of difficulty

EASY
• • •

This is a classic example of a repair gone bad. The previous owner of this door tried to sand out a scratch that went into the primer. That darker paint is the color under the clear coat.

Fixing Paint Scratches

**ANATOMY
OF A SCRATCH**

A FEW MINUTES' WORTH OF CAREFUL FILLING AND POLISHING CAN MAKE MOST PAINT SCRATCHES NEARLY DISAPPEAR. **BY MIKE ALLEN**

➔ **New car + parking lot = scratches and chips.** It's a fact of life. Other people often don't treat your car's paint with much consideration. Ditto for kids and pets, not to mention the odd troll with an attitude and a set of car keys. Respraying a car can cost thousands of dollars, while respraying a single panel may leave you with a clown car that doesn't match color left to right.

Fortunately, many small nicks, scratches and imperfections can be easily retouched. A careful job is unobtrusive and may well be almost totally invisible.

PROPER CONDITIONS: BE COMFORTABLE

Before you break out your touchup tools, figure out what you're dealing with. If the scratch appears thin and white, it probably hasn't penetrated through the clear coat.

INSIDE



STUCK STRIKER BOLTS + FOB GAMES + COLLAPSING BLEEDERS

DIY

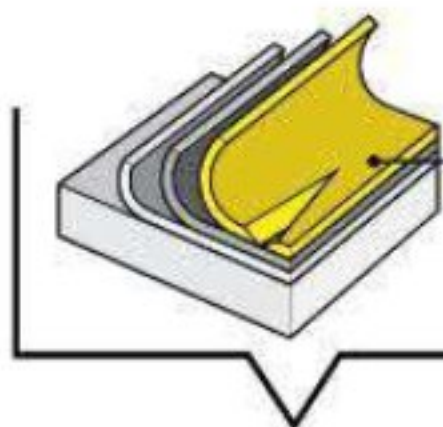
Auto PAINT AND CHIP TOUCHUPS

If it is body-colored or shows metal, you've got a deeper problem. Regardless, never try to touch up paint unless the temperature in your work area is shirt-sleeve-comfortable for you. The paint won't adhere, dry properly or gloss up. The ideal temperature would be in the 70s F, but 60 to 85 is acceptable. You'll need to be out of the wind and sun. Indoors is best, but a shady carport should do. The relative humidity should be less than 60 percent or so: The evaporating solvent will cool off the panel as it dries, potentially lowering the metal's temperature below the dew point and letting moisture condense on the surface. This is not conducive to good surface finish.

PATIENCE

Unless the car you're repairing is over 20 years old or was custom-painted, the paint is almost certainly a clear-coated catalyzed enamel. Artificially hardened by toxic chemicals, it's stable within hours of factory application.

On the other hand, the paint you're applying, whether it's primer, color or clear, is a lacquer. Lacquers dry because the solvent evaporates, leaving the solids



Clear-Coat Scratch

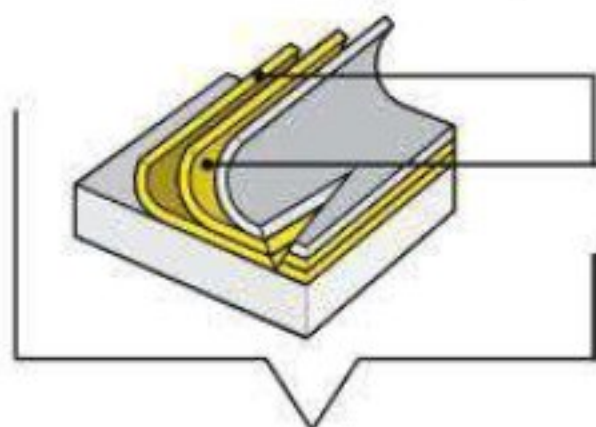
Minor scratches, ones that don't go through the clear coat into the color, or areas of low gloss or orange-peel texture can often simply be polished out with compound. Yes, this removes some of the clear coat, so polish the minimum area necessary or you'll have to respray some of that protective top layer. Thoroughly clean the panel after you're done to remove the abrasive compound.



[1] Clean the surface first to remove surface dirt. Masking nearby trim with tape might be wise, especially if it's chromed plastic. Apply a small amount of polishing compound to the pad that comes with it, or even to a terry cloth or microfiber cloth.



[2] Polish a small area. After a couple of dozen strokes, use a clean cloth to buff the area dry. Check your progress, and repeat if necessary. Go slowly to avoid sanding through the clear coat, and check often to see if the scratch is still visible.

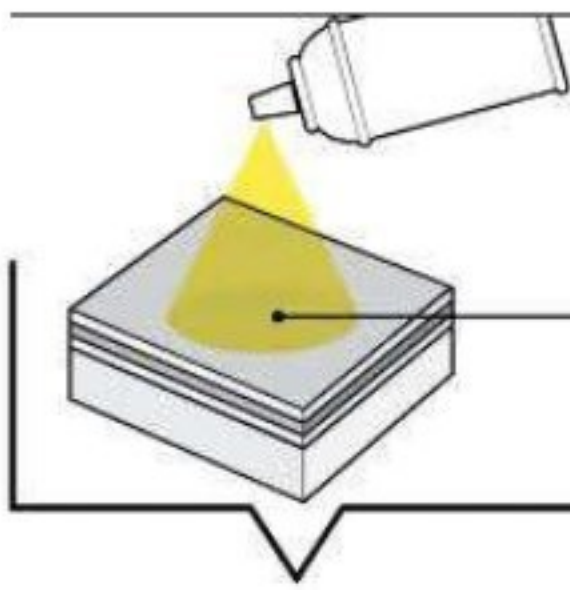


Base-Coat/Primer Scratch

You'll need to get some matching paint. This same procedure can be used to repair primer-coat scratches by brushing in a layer of primer first, then sanding the overrun until it covers only the bottom of the scratch. Don't skip that step: You'll have poor adhesion and/or rust.

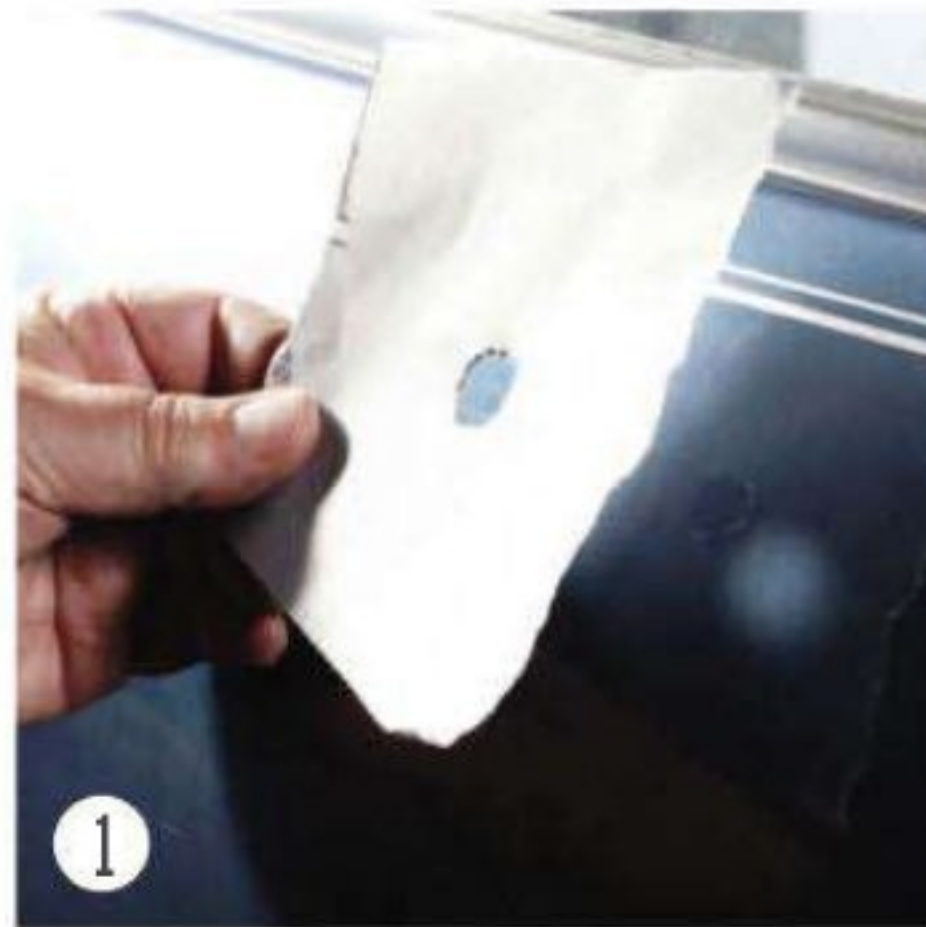


[1] Clean the panel with solvent to remove any oils or wax. Carefully apply primer or color to the scratch. Yes, you'll have paint overlapping the damaged area; it's okay, but work carefully and minimize any lap. **[2]** Let the paint cure at least overnight. With a sponge or rubber block as a backing, wet-sand with 600- or 1000-grit wet-or-dry sandpaper until any paint standing proud of the surface is gone. Work slowly, stopping often to clean the area and check your progress. **[3]** Use compound to chase the gloss back into the damaged area. This will keep the sanded area more closely contained. **[4]** You will probably have low spots. Apply more paint, and repeat until the scratch is filled and level. A final compounding should restore the finish's shiny factory gloss. Don't wax for 30 days to allow solvents to escape.



Spraying Clear Coat

Oops—if you’ve sanded through the clear coat or have repaired a deep scratch, you’ll need to apply clear coat. Buy a rattle can of automotive clear coat. Ordinary clear enamel won’t work—it has to be automotive paint intended for spot repairs. Dupli-Color and Rust-Oleum have appropriate products in aerosol cans. Here’s how to keep the repaired area small and unobtrusive.



[1] Clean the surface with solvent to remove oils and wax. Cut a dime-size hole in a piece of paper for smaller blemishes to avoid over-spraying—you could also mask the area. **[2]** Hold the paper a couple of inches from the panel and spray a light, dry coat through the hole. If it sags, you’ve sprayed too much. If it’s shiny, you’ve sprayed too much. Let this dry. **[3]** Using 600- or 1000-grit

wet-or-dry sandpaper on a sponge or rubber block, sand off any excess. This step is necessary to level the clear coat in the blemish, and also to keep the affected area from getting increasingly large as you add subsequent coats. As in a brush touchup, compound the affected area to remove sanding scratches. Repeat this process with at least two coats, allowing 24 hours between coats.

behind. While they may feel hard and be sandable within a few minutes, they will continue to shrink for a while. Allow lacquers to dry at least overnight so they can shrink before you add another coat. If you need multiple coats to build up the paint film to full thickness for a repair, one coat a day is best. Of course, be safe. The amounts of solvents used are small, but work in a well-ventilated area. Make sure to degrease the area with solvent before starting.

CRACKING THE CODE

Somewhere on your car should be the factory-paint code, probably on a sticker or metal plaque under the hood or in the doorsill. This will help a great deal in finding the correct touchup. It’s amazing how many similar colors there are in any car manufacturer’s palette in a single model year. If you can’t match the color in the display of touchup paints at the auto parts store, your next, albeit expensive, step is the parts counter at the car dealer, at least if you have a car that’s less than 10 to 15 years old. If you’re really stumped, an auto paint dealer can custom-mix you a pint; take in a sample, like the gas cap or a mirror. I’ve also gotten great matches from expresspaint.com and from their motorcycle counterpart, color-rite.com, where you can mail-order touchup pens and bottles, aerosol cans or quarts or larger cans of matched paint. **PM**

PRODUCTS:

Walk into any auto parts department and you’ll see a variety of kits and products. I’ve always had polishing compound and fine sandpaper around the shop. That’s really all you need, but it’s handy to have everything in one box. Some kits have the primer and clear already on board—all you really need in addition is the proper color paint and a place to work.



FROM LEFT: SCRATCHPRO’S DIAMOND-BASED COMPOUND COMES IN THREE GRADES AND CUTS FAST; THE QUIXX KIT HAS EVERYTHING, EVEN A POLISHING CLOTH; 3M’S KIT FITS ON A CORDLESS DRILL AND IS GREAT FOR LARGER REPAIRS; DUPLI-COLOR HAS A FULL LINE OF MATCHED PAINTS.

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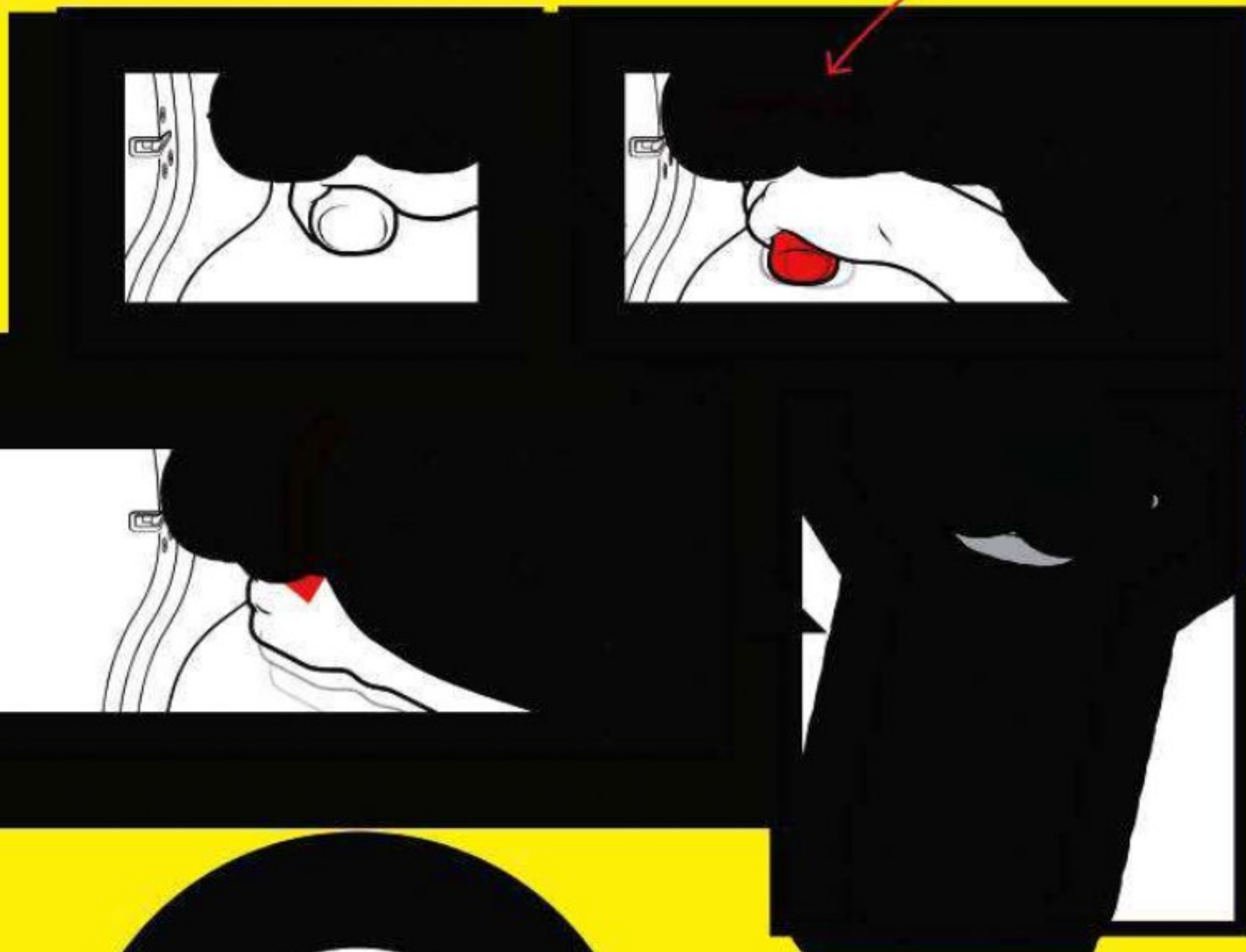
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Q+A



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Q

Mighty Tight

I'm trying to restore this beautiful-but-rusty sports car. I need to remove the door-lock mechanism from the sill, but the giant Phillips-head

screws used to attach it are really tight. I can't break them loose with a screwdriver; in fact, I ruined a nearly new screwdriver by trying to turn the shank with a pair of Vise-Grips. When I push hard enough to keep the bit from popping out, the screwdriver end gets chewed up. The screws must be made of some sort of really hard steel. Consequently, I'm afraid to try drilling them out. Besides, if I drill the heads out, I'll still have to deal with the stubs left in the holes in the doorframe. My buddy suggested heating the screws up with an acetylene torch, but I'm afraid I'd damage the paint or warp the thin steel panel. Any advice?

A I've always used a handheld impact driver to remove tough screws, but Graham Tool Co. sent me this nice little gadget last month that's even more effective. It's pretty simple. They call it the Small Fastener Removal Tool, and it's used in concert with a small air hammer. It comes with a socket adapter for small

bits, and I've found it useful for removing brake-disc-locating screws, CV-joint Allen-head bolts and even slotted wood screws. The rapid (dozens of times per second) in-and-out impact from the air hammer does two things: It busts up corrosion and loosens up stuck fasteners, especially when combined with some penetrating oil. At the same time, it keeps the bit firmly bottomed out in the fastener while you apply plenty of torque with your other hand. The combination has freed up fasteners that I otherwise would have had to resort to drilling out. Check it out at grahamtool.com.

Let Me In! ➔ I have a 1996 Buick LeSabre. The wireless key fobs (both of them) work to lock the doors and open the trunk but not to unlock the doors. Any way to fix this?

Okay, the transmitters in the fobs are working, as is the receiver in the car, or you'd get no response at all from the remote. I'm going to assume that you can unlock the doors with the central locking system from inside the car without the key fob or you would have mentioned otherwise. That leaves only one variable—the unlock button on the key fob itself. Times two, of course.

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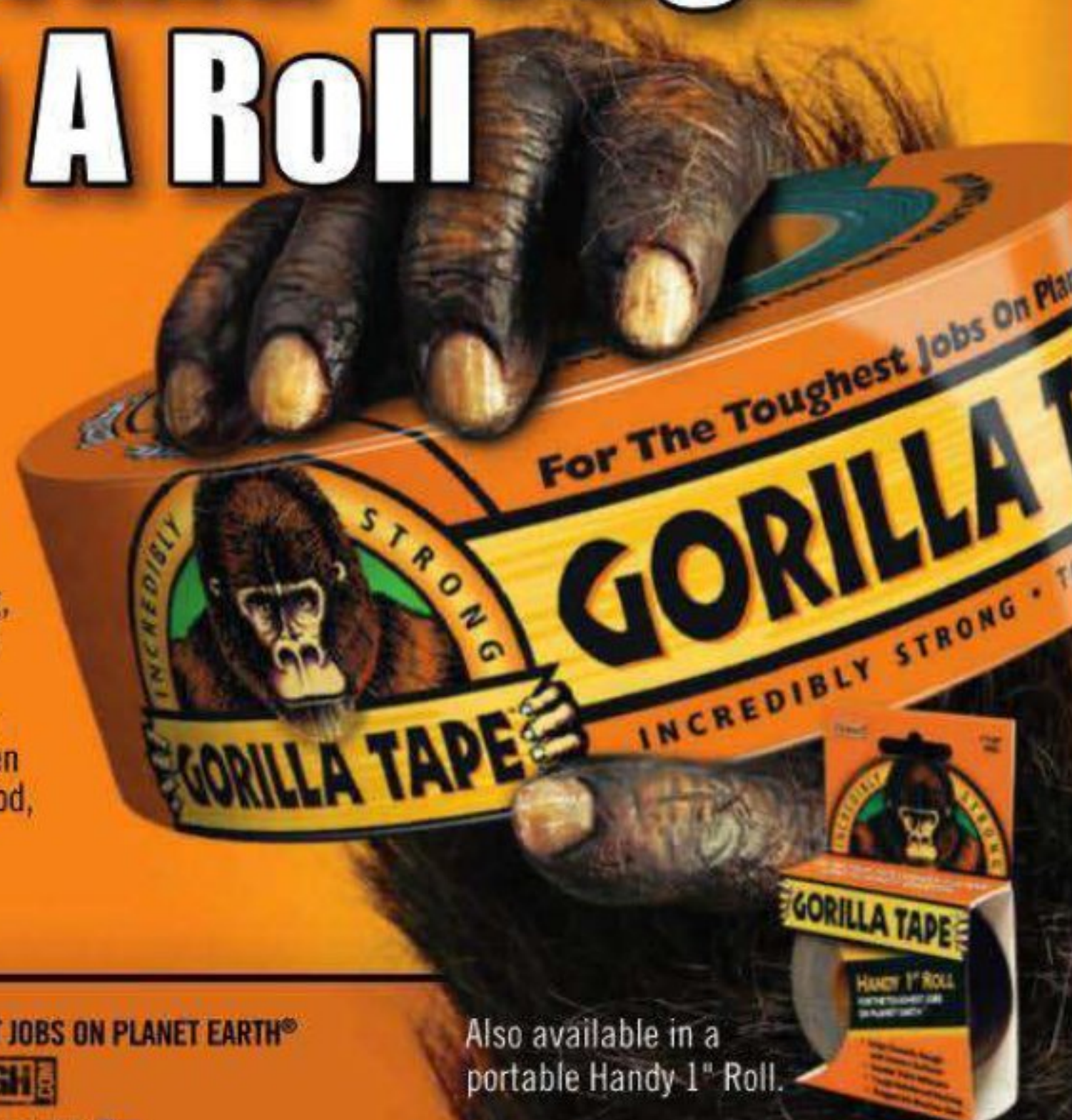
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Normally, when I have a bad key fob, I pick up a generic remote off the Internet or at the auto parts store and use the remaining working remote to program it. (No surprise, these units are far cheaper than the dealer-sourced ones.) Follow the directions on the replacement fob, since they're too complicated to list here. Unfortunately, in your case, both remotes aren't working properly, which makes reprogramming a new one tough. Here's a suggestion: Try reprogramming the receiver in the car. Turn the ignition key off. Use a short jumper wire to short the under-dash data-link-connector terminal 8 to terminal 4. Turn the key on. Press and hold the lock button on the fob; the doors should lock. Press and hold the unlock button; the doors should unlock. Remove the jumper. (Readers should note that this procedure is specific to a 1996 LeSabre and probably won't work on most other cars, GM or otherwise. As always, consult a shop manual or even the owner's manual for specific instructions relevant to your own car.)

All right, that probably didn't work, because, as I suspected, the key fobs are shot. I predict the issue is bad electrical contacts inside the fob. Pry or unscrew it open. Find the small microswitches soldered to the printed circuit board and hose them down with my favorite contact cleaner, DeoxIT. Try the

Got a car problem? Ask us about it. Send your questions to pmautoclinic@hearst.com or over Twitter at twitter.com/PopMechAuto or to Car Clinic, Popular Mechanics, 300 West 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.



lock button again. If that works, immediately acquire a generic fob and use the now-functioning OEM fob to program it, because odds are it will fail again sooner or later.

Out of Control ➔ Is anyone coming up with a decent cruise control? Engine sizes are coming down and efficiencies are going up, but the power-to-weight ratios cause the engines to redline in hilly country when the cruise pushes the pedal to the floor. What is needed here is an engine-throttle limiter that would work up to the requested top speed more slowly. In my four-cylinder Ford Ranger I would be much happier with the speed selection being more of a suggested upper limit than a demand.

The problem isn't in the cruise control. As you suggest, the power-to-weight ratio is



MIKE'S SHOP SHORTCUTS

THE RIGHT SIZE



I hate brake work—well, at least when someone brings me some neglected car or truck that hasn't had any scheduled maintenance since the Nixon administration. Any kind of brake work—whether it's something episodic like replacing a failed brake pipe, or periodic maintenance—means bleeding the brakes.

Hah. You try turning those minuscule, 7-mm hexhead bleeder bolts after they've marinated in salt water, brake dust and mud for a generation. They're made of fairly soft steel (probably so the tapered valve seat at their inside end has a chance of sealing properly against the hard, cast-iron seat inside the caliper), and that means they round off easily.

First rule: Use a box wrench or six-point socket to break them loose.

When they do round off, the first thing most people try is to grip them with Vise-Grips. Nope, see above for discussion of soft steel. If you reef down enough on the Vise-Grips to get good purchase, the soft steel (ditto) bolt, which is hollow, will collapse and

break off clean at the surface of the caliper.

To avoid the collapse, I fill the hole in the center of the bolt with the shank end of a twist drill, choosing one from the drill stand that just barely fills the hole. It keeps the bleeder bolt from squashing flat, and because it's smooth, it's easy to extricate later.

PHOTOGRAPH BY CHAD HUNT



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lower on many small vehicles. This necessitates more throttle to negotiate hills, which in turn eventually makes the transmission downshift with a bang to try and maintain speed. Some manufacturers, specifically ones with a more expensive product than your Ranger pickup, have engine controls with more intelligence: They are less prone to downshifting when in cruise-control mode than not, specifically to avoid this issue, which is referred to as hunting. On longer hills, the vehicle will go back and forth repeatedly between two gears as the transmission searches for the sweet spot.

I do have one suggestion for you: Some aftermarket cruise controls are adjustable as to how aggressive they are. If this problem really annoys you, disable the Ford cruise control, install an aftermarket system, and tune it down. By lowering the sensitivity, the vehicle speed will sag more on hills, reducing—but not eliminating—downshifts and hunting.

Supersaver ➔ When I think I'm going to be stopped in my car for 20 seconds or more, like at a drive-through window, I shut off the engine. My son argues that it is going to take more fuel to restart the engine than I will save by shutting it off. Is there some rule of thumb on the break-even point for shutting off versus letting the engine run?

Engines consume gasoline while idling—2 to 5 gallons per hour. They consume *no* gasoline when shut down. It takes essentially *zero* gasoline to restart a warm engine. Do the math. That's why hybrids and some new cars shut down the engine at traffic lights—to conserve fuel—restarting automatically when your foot comes off the brake so the car is ready to go by the time you get to the gas pedal. I don't know where this misconception came from, but it constantly comes up in my mail.

Actually, I think I may know where it came from. In days of old, when cars had

carburetors and chokes, a cold start involved closing the choke to make the mixture richer, sweetened by a few pumps of the accelerator, which pumped a half-spoonful or so of raw gas into the intake at every stroke. The extremely rich mixture ensured that enough gasoline was in its vapor (not liquid) phase when the spark plugs fired; otherwise, the wet gasoline drops wouldn't ignite. Once the engine caught, the choke had to stay on for several minutes, or the cold valves and piston would keep the gas liquid. It would take several minutes of fast idling or choke-on driving to bring the engine up to normal operating temperature. That, of course, consumed fuel more rapidly until the engine warmed up. An inappropriate generalization from that phenomenon may have led to the misconception that engines (modern, fuel-injected engines that are already warmed up) need substantial amounts of fuel to restart when shut off briefly.

One downside: You may need to replace your starter motor prematurely. Vehicles with idle shutoff use either an uprated starter or combine the starter function with a hybrid traction-assist motor.

Braking Bad ➔ Back when I learned to drive, my dad taught me to always apply the parking brake before shifting the transmission to park. He told me that this served two purposes. First, applying the parking brake before shifting the transmission into park took the pressure off the transmission, thereby preventing the failure of the pin that drops into the transmission when shifting into park. Second, applying the parking brake recalibrated or reset the brake cable, thereby keeping the rear-drum brakes in optimum operating condition. Recently, I took my 2000 Toyota 4Runner into the shop for scheduled maintenance. The technician recommended a brake job, which seemed reasonable given the number of years since the last brake job. Somewhere in our conversation I mentioned that I always use the parking brake, and the technician gave me the business about my excessive use of it. This leads me to two questions for you. First, was my father correct in what he taught me 30 years ago? Second, do those same lessons hold true today on these new-fangled automobiles with their fancy disc brakes and such?

Your father was right on the money. Still is. Regular use of the parking brake—often erroneously referred to as an emergency brake—is a good practice. I do think the advice about taking the pressure off the parking pawl is probably overcautious, unless you live on a steep hill or someplace where your parked car is likely to be creamed by passing traffic. Keeping the parking-brake cable from freezing up from disuse, however, is good advice, even today with four-wheel disc brakes being commonplace. If the cable doesn't get regular exercise, it'll freeze, especially the part of it that's hanging below the chassis and is constantly bathed in salty water and grit. Ditto for the self-adjusting system built into the rear backing plate or rear caliper. **PM**

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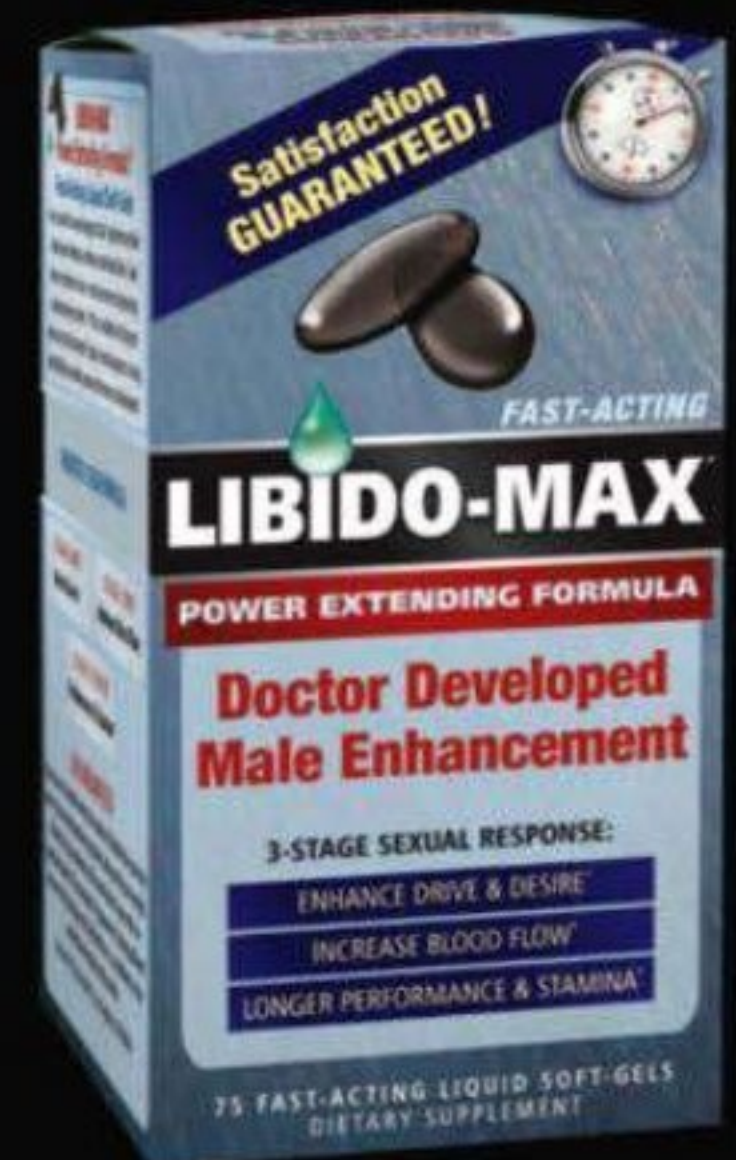
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When Ryder Washburn graduated from college, he had a decision to make: pursue a career in finance or go into the family business—a company called The Specialists Ltd., which provides weapons for films and television shows. “It turned out that doing armory work was a lot more fun,” he says. Washburn started on TV shows such as *Law & Order*; now, 11 years later, the armorer visits sets along the East Coast, maintaining weapons for *The Bourne Ultimatum*, *Salt* and other movies. The company’s seven armorers work on up to 10 movies and 15 TV series at a time. “If a movie were a Nascar race,” he says, “we’d be the pit crew.” The firm is moving beyond guns: “We started doing fabrication three years ago,” Washburn says. “Making those props—like the catapult for *The Smurfs*—is the most fun.” — ERIN MCCARTHY



1. AK-47 VARIANT

This firearm is a Chinese version of the world’s most widely manufactured gun: the Avtomat Kalashnikova 47. Movie sets never use real bullets, so, like all the semiautomatic weapons in The Specialists’ arsenal, this AK has been modified to shoot blanks—cartridges that contain gunpowder but no bullet or shot. “Guns are designed to work with real bullets, and blanks don’t have the same operating principles,” Washburn says. “The modifications are different for every gun.”

2. BLOOD KNIFE

For scenes where an actor appears to get cut, productions use blades like this World War I trench knife. “A pipe inside the blade is hooked up to a tube of pressurized blood,” he says. On cue, the knife-wielding actor slashes—and holes in the dull blade funnel fake blood onto the victim, creating the illusion of a gash.

3. NONGUN

One of the most popular “weapons” used in films and television—including *The Sopranos*—is the nongun, which contains a circuit board and electrically fired charges that simulate gunfire. “It looks like a gun,” Washburn says, “but it’s made from scratch, not out of any gun parts.” Nonguns are great for situations so risky—like when a character is shot close to the head—that even using blanks is too dangerous.

4. ROCKET LAUNCHER

This genuine AT4 rocket launcher is an antitank weapon used by the U.S. military. “They’re considered disposable,” he says, so they modify them for use on sets.

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IT'S DIFFICULT TO PICK ONE GREAT THING TO SAY ABOUT THE NEW 2011 JOURNEY. IT HAS 67.6 CUBIC FEET OF STORAGE, AN ALL-NEW REFINED INTERIOR, AVAILABLE INTELLIGENT AWD, OPTIONAL SEATING FOR SEVEN AND TOP SAFETY PICK HONORS FROM THE IIHS. SO YES, PICKING JUST ONE THING IS PRETTY MUCH IMPOSSIBLE.

DODGE

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